PHYCOLOGIA INDICA

(Icones of Indian Marine Algae)

K. S. SRINIVASAN

Vol. II

1973

THIS BOOK—*PHYCOLOGIA INDICA*

In continuation of the first volume of this series, in the present volume, fifty-three ICONES of Indian Marine Algae are depicted, together with one plate on Diatoms, prefaced by a general account of the more important economic uses and industrial applications of the sea-weeds, as obtained in some of the progressive countries in the world, to illustrate the enormous vegetable wealth of the sea that awaits exploitation.

PHYCOLOGIA INDICA

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TO

LATE PADMASHRI REV. FR. DR. H. SANTAPAU, S.J.

Ph.D (Rome), Ph.D (Lond.), A.R.C.S., D.I.C., F.N.I.

EX-DIRECTOR, BOTANICAL SURVEY OF INDIA
WHO BY HIS SUSTAINED RESEARCHES IN PLANT TAXONOMY AND SYSTEMATICS
RENDERED VALUABLE SERVICES TO SCIENCE AND TO THE COUNTRY

THIS HUMBLE WORK IS DEDICATED
BY THE AUTHOR
AS A MARK OF DEEP RESPECT AND AFFECTION

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INTRODUCTION

The teeming life which Nature abounds
Is treasured secret in solemn grounds
For man to bring to his knowledge door
The wonder gift of the Ocean floor.

—*Srinivasan.*

All lovers of sea-weeds will doubtless recall many a pleasant ramble in spots along the sea-shores, which to the un-initiated, would appear hopelessly unlikely to yield any useful purpose. It is precisely in such and similar spots that intense searches for marine algae are to be made, for species that are not to be easily found. The rocky shores, the shingle and coralline reef-coasts, creeks and inlets, the sandy stretches of inter-tidal sea-floors sprinkled with dead shells and dead or living corals, the lagoons and the sub-littoral regions are rich with a vast assemblage of blue-green, green, brown and red sea-weeds. Yet, the generous beauty of these innumerable sea-weeds is not fully appreciated by many. In the first volume of "*Phycologia Indica*", an account of some selected Indian sea-weeds with which Nature so generously decorates the Ocean floor was given. Fifty one species were described therein from the Indian Coasts, and for each species, colour illustrations and descriptive notes as to their diagnostic characters, ecological features of interest etc., were given, prefaced by a general account as to their occurrence, distribution, collection and preservation methods and maintenance of sea-weeds for future study purposes, thus providing the supplementary knowledge that every sea-weed lover may desire to possess.

The present volume is in continuation of the earlier one, setting forth a set of another fifty-three species, and following the same pattern as adopted in the earlier publication. A brief account of Diatoms (Bacillariophyta) is also included. It is considered useful to give in some detail the economic and industrial applications of sea-weeds in general in this volume, which might help to enable one to appreciate the great potentialities that lie before us with the available sea-weed resources in our country, against the background of the great strides made in other countries in commercial exploitations and industrial application of sea-weeds which are occurring rich and in plenty along those coasts. In attempting to give here an account of the many economic aspects of sea-weeds, it should be prefaced that this account merely professes to give a very brief epitome of the uses to which the sea-weeds are put to in other countries, which might appropriately throw much light on the possible lines of developments that may be attempted in our country even with our own available, though limited raw resources of marine algae.

ECONOMIC ASPECTS OF SEA-WEEDS

Sea-weeds were generally considered as least attractive or useful, ere long much was known through science of their economic potentialities. W. G. Johnstone and A. Croall, in their beautiful work "the Nature Printed British Sea-Weeds, Vol. IV, 1860" have aptly quoted the words of Horace, the Latin Poet (65 B.C.—8 B.C.) which may be repeated here. Horace, when adverting in his Fifth Satire to the Schemes of unscrupulous ambition says—"*Et genus, et virtus, nisi cum re, vilior alga est*" i.e., family and virtue without wealth are even more worthless than a sea-weed. But now, the story is entirely different. Few of our wild plants are, perhaps, more economically important than our present examples; for, the sea-weeds are now known as excellent examples of the great diversity of uses which plants may offer to the economic wealth of a country. In the following pages, some of the more important economic aspects of sea-weeds and their industrial applications, as obtained in some of the progressive countries in the world, are, therefore, given.

Sea-weeds as shelter for marine animals

Dense growth of sea-weeds, especially the brown sea-weeds, some species of which attaining great sizes and growing in profusion, offer shelter places for several marine fauna in the sea.

Sea-weeds as food for marine animals

The chief use of sea-weed is as source of nutrient of myriads of animal life in the sea which feed directly on them and prey on other animals as well. Besides the larger species, the microscopic organisms, such as Diatoms, occurring as thick planktons, or as epiphytes, form also the chief source of food, especially for Molluscs, Crustaceans, Tunicates, Fishes etc.

Sea-weeds as fertilisers

It is known that for many centuries, sea-weeds were being used as fertilisers to increase crop yields in countries with extensive sea-coasts. Several species of rock-weeds are used as manure, in various coastal countries, the sea-weeds being allowed to rot on the surface or composted with other organic materials. Sea-weeds contain greater % of potassium salts, about the same % of Nitrogen, but smaller % of Phosphoric acid than does manure. Sea-weed manure is valuable because of the trace-elements they contain.

Potato fields are known to be largely supplied with sea-weed fertilisers, using the larger brown sea-weeds, *viz.*, the *kelps* in Alaska and France. *Egregia merziesii* is largely used as fertiliser in W. coast of America. Several species of *Laminaria* are used as such in Northern parts of the Pacific and Atlantic coasts of U.S.A. In Monterey, Santa Barbara and in many localities in California, considerable number of species are used as fertilisers.

Sea-weeds as source of commercial Iodine

Some of the larger brown-sea-weeds, such as the species of *Laminaria, Fucus, Ecklonia,* which are commonly known as *kelps*, have been the source of commercial *Iodine.* During the World War I, France and U.S.A. harvested huge quantities of sea-weeds for this purpose.

Along the north coasts of U.S.A., plenty of brown sea-weeds occur. *Laminaria* was used as a chief source of Iodine by U.S.A., during World War I, and large quantities were used, pulped and allowed to ferment producing acetic acid. After extraction of Calcium acetate, the residue was worked for *Potash* and *Iodine.* With new cheaper and more readily accessible sources available, sea-weeds are no more used for Iodine in U.S.A.

Scotland produced most of Iodine from marine plants. About ten species are used for this purpose, and among them are *Laminaria, Alaria, Sargassum, Ecklonia, Fucus* and *Ascophyllum.*

Comparatively, Iodine industry is of recent origin in Japan. Hokkaido, Kanagawa, Yamaguchi, Schzucka are the chief localities in Japan for Iodine manufacture from *kelp.* About 5-7% of world supplies is from Japan, that country producing about 100 tons of Iodine per annum from *Laminaria, Ecklonia, Eisenia* etc.

In Russia, *Phyllophora nervosa* from Black Sea is used and by electrolytic methods, *Iodine* is extracted.

Sea-weeds as Potash yielders

Several kinds of sea-weeds are burnt to supply *alkali* for manufacture of soap and for the preparation of *alum* and in the manufacture of glass of superior quality. The *Giant kelps,* and the *Bull kelps,* such as *Macrocystis, Nereocystis, Pelagophycus* and a few others are best known potash yielders, as *potassium chloride,* as high as 30% dry weight.

Germany made the world supply prior to World War I. Pacific coast of N. America and Canada have very extensive areas of *Laminaria, Macrocystis, Nereocystis, Alaria* etc. America use these as source of *Potash, Macrocystis* yielding 16%, *Nereocystis* 18% and *Alaria* 7%.

Sea-weeds as stock-feed

In Europe, America and in many coastal farms, sheep are grazed on the coastal strips during low tides, feeding exclusively on sea-weeds. In Orkney Is., this is a known practice. In Europe, a number of factories are established for preparation of stock-feed from *Fucus, Ascophyllum, Laminaria* and other sea-weeds. This has become an important agricultural

activity in many of the coastal towns. In N. Scotland, several sea-weeds are used successfully in cattle feeds and also in feeding pigs and sheep. In Great Britain, sheep are known fed on sea-weeds.

The butter and fat content of milk are known to increase and the health of flocks is stated to improve considerably. Calving becomes easier and the off-springs are known to be healthier. The carotene contents of sea-weeds are important as stock-feed. For Vitamin A, the value of carotene is known. In these respects, *Ascophyllum* and *Fucus* are valuable.

Sea-weeds as Poultry-feed

The Iodine contents of eggs can be increased considerably by administering sea-weed meal. Though claims were made for *Ascophyllum* feed as leading to more storable eggs, this has not, however, been established. Poultry fed on sea-weeds show brighter plumage, increased weight, alertness and the % of egg hatching is known to be remarkably improved.

Sea-weeds as human food

From the earliest times, man has utilised sea-weeds for food and medicine, besides using them as fertilisers. In many parts of the world, sea-weed is used as food and the greatest use is, however, seen in Japan, China, Hawaii and Brazil, where hundreds of kinds are used for food.

In Japan, with more than 306000 km of coast line, the quantity available by way of sea-weeds is enormous. In Europe also algae were once much used, but now the use of algae as food is much less. *Laminaria saccharina, Rhodymenia palmata, Porphyra tenera, Alaria* sp., *Undaria pinnatifida, Eisenia* sp., *Codium* sp., and several others are eaten raw also. The Hawaiins, like the Japanese, eat sea-weeds and about 70 species are known used as such. *Chondrus crispus* is a most important edible sea-weed in U.S.A. *Porphyra laciniata*, the *laver* is much priced in the entire coast of America and is boiled and served with butter, pepper, vinegar and also used as dressing for cold meat. *Rhodymenia palmata*, the *dulse*, is used as food in many parts of the world as relish, chewed like gum, eaten raw or with fish. During famine in Ireland, *dulse* and potatoes formed the staple food in the coastal areas.

Among the various other sea-weeds used as food, mention may be made of *Ecklonia, Cystophyllum, Phylloderma, Phyllitis, Chordaria, Ulva* sp., *Ulva lactuca, Mesogloea* sp., *Sargassum* sp., *Nemalion, Grateloupia filicina*, etc.

Sea-weeds as a class contain large amounts of carbo-hydrates, sodium and potassium chlorides, as well as smaller amounts of protein and fats. About 65% of dry weight of most edible algae is composed of complex carbo-hydrates, with rather low digestibility of about 67% only, which is much lower than any other carbo-hydrates of common food-stuffs. The polysaccharides, carbohydrates and hemi-cellulose groups of *galactan, pentosan, levulan, mannan* etc. found in edible algae are not easily assimilable in human beings. But sea-weeds are relatively high in certain vitamins, in vitamins A and E, as well as in valuable inorganic salts needed for human body. The Iodine content is valuable in glandular treatments. Several brown sea-weeds yield *mannitol*, a sugar alcohol and other food resources as *laminarin* and fats. The sea-weeds, though not highly nutritive, are yet of value due to their colloidal substances, thickening and jelling and stabilizing properties.

INDUSTRIES BASED ON SEA-WEEDS

The Isinglass or Kanteen industry

The Isinglass or Kanteen industry is important in Japan. *Vegetable Isinglass* is composed largely of *gelose* or *pararabin*, a substance remarkable for its gelatinising properties. It is insoluble in cold water, alcohol, dilute acids and alkalies. *Gelose jelly* keeps well also. *Gelidium corneum* and *Gelidium cartilagineum* are much used for this industry. It is used in Japan as food, in jellies, in soups and sauces, in pastries, desserts etc. It is also used in sizing textiles, for stiffening of warp of silks, in claryfying wines and in making moulds for plaster of paris modelling. It is also used in the manufacture of paper. In China, it is used as substitute for edible bird's nest. It also finds use in biological work, and as biological medium. Isinglass is imported to India.

Funori or Sea-weed Glue industry

Funori industry is also important in Japan. Several species are used in this, and the product is chiefly used in stiffening fabrics. *Gloiopeltis intricata* is largely used and the alga is also cultivated. Hokkaido in Japan has the most important industries in these.

Funori finds extensive application in glazing, as starch for clothing, for coating papers, for cementing walls and tiles etc. It is marketed to Europe. The Japanese women are known to cleanse their hair with thin solution of *Funori*. It is exported to Korea, China, Asiatic Russia, England and France, from Japan.

Kombu industry

Kombu is one of the most important marine vegetable preparations for which the larger brown sea-weeds, the *kelps*, are much used in Japan. In Japan and China, enormous sales are effected on these products. *Kombu* is exported to E. Indies, San Fransisco, America etc. The principal centre of the industry in Japan is in Osaka, Tokyo. *Lamınaria* species are used as the base. The products are used in packages, and as food, entering into the dietary of every Japanese family. *Kombu* is also used in tea. Green dyed *kombu* is exported to China.

Amanori or Laver industry

In this industry, *Porphyra* is used. Cultivation of *Porphyra* is a famous industry in Japan, extensively seen in Tokyo Bay, Hiroshima and other places. More than 2245 acres of sea-bed are known under cultivation. *Amanori* is a nutritious food. It is a popular food in the British Isles also.

Agar—Agar industry

Agar is another important product obtained from certain kinds of sea-weeds, commonly termed as *agarophytes*. *Agar* is the commercial name given to the dried gel extract from certain species of red sea-weeds, by bleaching, clearing, freezing at temperature about —10°C. and removing the water by melting. It is about 75% gelose, 15% water, 4% ash and with a smaller % of protein, fats, fibres and silica.

Japan developed the industry to the highest degree first. Then in 1930, Russia undertook and developed the industry. Industrially, a number of companies in United States are engaged in *agar* manufacture. In California, *agar* industry has established well. For many years Japan has been the principal producer of *Agar*. About 2000 metric tons/yr. are produced and the principal source is *Gelidium amansii*. In Orient, besides Japan, agar industry is established in China, Malaysia and Ceylon.

After World War II, many other countries explored the coast lines for *agarophytes* when the agar supply from Japan was cut off. Along the Pacific coast of America (*Gelidium cartilagineum*), S. Africa (*Gracilaria verrucosa*), Carolina, S. Africa, Australia (*Hypnea musciformis*), Ireland (*Chondrus crispus*, *Gigartinia stellata*), England (*Suhria vittata*) and New Zealand (*Pterocladia capillacea*), extensive surveys revealed rich resources of *agarophytes*.

Agar-agar is favourite in Japan and China for jelly and used as thickener for soups, sauces, in ice-creams, dessert, pastries etc. It is used in sizing fabrics, in the paper manufacture, glue manufacture, and to add gloss and stiffness to leather. It is used in cosmetics, in medicines, in pharmaceutical emulsions, in tablets etc. Its use in water base inks and insect sprays are also well known. *Agar-agar* is even superior to jelatine in giving rigidity to soft canned fish in transport. It is used in clarifying liquor. In America and Europe, *agar* finds extensive use in bacteriological work. *Agar* is used as a laxative, and it has properties of absorbing much water and becoming lubricant and serving as mild stimulant.

Algin industry

Another very important reserve in brown algae is *algin*. It is a colloidal substance, of complex compound of d-manuric acid and has wide extraction and utilisation. It is an

alginic acid, and many metallic alginates may be obtained from it. The most useful, however, is the *Sodium alginate.*

Algin is used in a number of industries particularly as "protective" colloid, in suspensions and emulsions. Among the chief use of *alginates* are, as sizing materials, in waterproof varnishes, as dyes, as rubber-algin substances, used in the manufacture of knife-handles, buttons, combs etc. *Sodium alginate* has found wide spread use as stabilizer in diary products.

Barium alginate is used for making fire proof materials. *Calcium* or *Sodium alginates* dissolve in water to give a thick viscous liquid and this can be spun into an artificial silk thread. By replacing the *Calcium* or *Sodium* with *Chromium* or *Beryllium*, a resistant thread can be obtained. *Alginates* of heavy metals, which are not soluble in water, form plastic materials.

Algin is used as a stabilizer for ice-creams, sherbets, as fillers, as salad dressings, as polishing materials and the insoluble salts used in producing water proof cloth. Recent experiments with *algin* have shown this as useful as an ameliorator of poor soil conditions. *Alginyl stearate* is extensively used in the manufacture of film—forming products for coatings which is resistant to scratches. A glossy insoluble surface results from use of ammoniated alginate of *Aluminium. Sodium alginate* is used for fixing mordants and as substitute for various salts in precipitating mordants to the dyeing industry, where cotton yarn is used. It is also used for resolving and preventing incrustations of boilers.

Several surveys were conducted during 1939-1945 along the Pacific coasts of N. America for *algin* sources. In New Zealand, extensive surveys were made for *Macrocystis* and in Great Britain for the *rock-weeds* (*Fucus, Ascophyllum*) and *oar weeds* (*Laminaria*). New devices have been employed for harvesting, with grapnell echo-sounder, and aerial photography. Considerable work is also done in other countries, since World War II, on the biology of sea-weeds, on their regeneration, conditions of reproduction, and chemical compositions, together with researches on *agarophytes* and *algin* suppliers. In many Western countries, as in America, Germany, England, and others, large scale industrial firms have been established to process the sea-weeds and manufacture *algin*, and *alginic acid* and its compounds, with encouraging results.

Other uses of Sea-weeds

The local fishermen in Japan and in some of the Western countries, use *Laminaria* as a vegetable barometer, to indicate the weather conditions, storms etc., depending on the nature and changing condition of its stipe. The dried sea-weeds are heated in a retort, and by this char-process, *Ammonia, Soda, Potassium* and *Iodine* are obtained along with *charcoal.* The *charcoal* thus obtained is mixed with *algin* and used as *carbon cement* for covering boilers and in boiler treatments. The *Giant* and *Bladder kelps, Nereocystis,* which grows to enormous sizes, reaching more than 90 metres (300 ft.) with its tufts of leaves more than 15 metres (50 ft.) long, have strong flexible stems, which are used by the natives as fishing lines.

Series of experiments have been conducted in Sweden on the occurrence of Vitamin B_{12} in marine algae. It has been found that Green algae are generally richer in Vitamin B_{12} than Red algae, and lastly the brown algae. The Irish moss (*Chondrus crispus*) is used in preventing scurvy and goitre and valued for its *antiscorbutic vitamins* and large amounts of *Iodine, Bromine, Calcium, Magnesium, Potassium* salts.

Certain sea-weeds have antibiotic activity. Ethyl-alcohol extracts of *Ascophyllum nodosum* and *Rhodomela larix* possess inhibitory activity. Quite a number of brown sea-weeds have been experimented for antibacterial activity. Among them are, *Ascophyllum, Fucus, Halidrys, Pelvetia, Laminaria, Polysiphonia, Gigatinia, Rhodymenia* and a few other red-sea-weeds have also been shown to have the same properties.

Mannitol, a sugar alcohol of mannose, is a valuable product obtained from several brown-sea weeds. It is used as a sweetening agent for diabetic patients. It is also used in the manufacture of high explosives, by replacing glycerine, the *hexanitro-mannitol* is known as a very powerful explosive. Esters of *mannitol* with common fatty acids yield excellent vegetable oil substitutes, and the *manno-mono-oleate* is claimed to possess the same nutritional value as butter fat.

Some of the insoluble alginates such as *Calcium, Zinc, Aluminium* and *Iron alginates* are considered very useful in the manufacture of distemper base. *Sodium alginate* is useful in the creaming of rubber latex.

Work done in India on sea-weeds

While so much advance is made in other countries on the commercial and industrial applications of sea-weeds, in India, not much use is made of Indian sea-weeds. According to one estimate, the Pamban area, Cape Comorin and the Chilka lake in Orissa, yield about 13.08 metric tons/yr. of weeds yielding about 4.64 metric tons of *agar*. Among the agarophytes experimented, mention is to be made of *Gelidium*, *Sarconema*, *Hypnea*, *Gracilaria* and a few others. It is also estimated that among the Indian sea-weeds, *Sargassum tenerrimum* yields 34.6% of *alginic acid* and *Sargassum wightii*, 29.8%. The *mannitol* content of the above sea-weeds is estimated at 9.4% and 7.3% respectively.

Considering the vast strides made in other countries, Indian researches on sea-weeds present quite a contrasting picture, as not even the fringe of the problem appears to have been touched. Much still remains to be done with the marine algae in India, by way of extensive as well as intensive surveys, quantitative and qualitative, to assess the wealth of our sea-weed resources, to use them as sources of marine commercial products. The researches initiated in these respects in some of the research Institutes, as at the Central Marine Biological Research Station at Mandapam, and Central Research Institute at Kerala, in South India, as part of the Fisheries development schemes, and in the Marine Biological Research Institute at Bhavnagar, are promising indications of progressive trends in sea-weed researches to evaluate commercially the possibilities of extracting marine algal products.

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LOPHOCLADIA LALLEMANDI (Mont.) Schmitz

Plants with an intricately clumped thallus, attached to small dead coralline pieces on sandy floors, by means of tiny basal portion. *Fronds* several, 8-10 cm in height or more, cartilaginous, articulate. Lower portions of old branches subcorticate, tetrasiphonous, branching without any order. *Secondary branches*, fastigiate; branchlets smaller, arising alternately. *Filaments* forming a knot, villose, monosiphonous, cylindrical, 1½ mm long, shortly and widely dichotomous towards the base, rest, simple and very long. *Transverse section* of thallus with 3 central cells, increasing from 3/4 of base gradually to 8-10 cells in ultimate ends. *Filaments* in spiral rows or in tufts. *Procarps*, developing at base of trichoblasts. *Colour*, beautiful purple rose. *Substance*, cartilaginous, filaments very thin and membranous. Plants adhere firmly to paper on drying.

Habitat : Hare Island, off Tuticorin, Pearl-Bed, Tuticorin; Pamban.

The plants were found growing attached to small broken pieces of dead corals which are well buried under coarse-grained sand, on the shore, near about high tide mark, being bathed by the rolling and gushing waves during high tide, and at low tides, exposed, occasionally only being washed or sprayed by sea water. Being very delicate, the alga should be transferred to herbarium immediately on collection to preserve its beauty. It occurs as a rare alga in Tuticorin, Hare Island. The alga seems to have its distribution in Red Sea, Somali, E. Coast of Africa, Borneo, West and Mid-coasts of Australia etc.

PLATE I

LOPHOCLADIA LALLEMANDI (Mont.) Schmitz
(× 1.5)

HALYMENIA FLORESIA (Clem.) Ag.

Plants large with minute basal holdfast. *Frond* flat, without veins or midrib with a very slender stipe, becoming cuneiform higher up and gradually broadening into the base of a broadly linear lamina. *Lamina*, compressed or flat, gelatinose, membranaceous, slippery; more than 45-50 cm long and 15 cm or more in width; dichotomous or pinnatifid, set with lateral branches. *Branches*, with second and third series of lesser dimensions, broadly linear or oblong cuminate and spreading, entire or serrate-lacerate, ciliate. Ramifications and sizes of branches much varied. Apices of branches and branchlets acute. *Medulla*, with laxly inter-laced branching filaments. *Fructifications*, immersed in the tissue of thallus. *Tetraspores*, scattered throughout the surface. *Colour*, bright pink-red to blood red, often on exposure getting bleached to dirty red, yellowish and then to white. *Substance*, gelatinous, tough. On drying, plant adheres firmly to paper.

Habitat : In deeper waters; Chank Fisheries, Rameswaram; Pearl-beds, Tuticorin and Hare Island; Washed ashore, Dhanushkodi, Pamban etc.

The red-alga illustrated here is another beautiful species of our coasts. It is seen washed ashore at Dhanushkodi during stormy months, evidently brought from deeper waters. At Chank beds and Pearl-beds, at Rameswaram and Tuticorin, the alga is seen flourishing in deeper waters. Being very delicate, the alga does not stand desiccation. Its colour sooner or later fades and turns to yellowish and utlimately to white on exposure, the whole plant looking like a white, translucent membranous, somewhat cartilaginous structure.

HALYMENIA FLORESIA (Clem.) Ag.
(× 0.8)

HALYMENIA CEYLANICA Harv.

Plants somewhat bushy, soft, fleshy consistency, membranous with one or more blades from a disc. *Frond*, 1-1.5 cm broad, with numerous lateral branches. *Lateral branches*, 1 cm thick, variously lobed. *Proliferations*, numerous, narrow from the margin, abundant at apices; more or less flat, 1-3 cm width and 2-4 cm long. *Medulla*, made up of slender filaments. *Cortex*, with large cells inside; outside and towards the surface becoming smaller. *Spermatangia* on blades in small sori. *Cystocarps*, borne on outer portion of medulla, immersed in thallus. *Tetrasporangia* and *Cystocarp*, in special fertile branches. *Colour*, deep to dark red. *Substance*, membranous to gelatinous, fleshy. Plants adhere to paper very firmly.

Habitat : Pearl Banks, Tuticorin; Rameswaram and Dhanushkodi, washed ashore; Andamans Is.; Nicobar Is.

The red-alga illustrated here is a rare species to the Indian coast proper. *Halymenia floresia* is a more common species in the Gulf of Manaar, and *Halymenia venusta* from Okhamandal seas. During heavy monsoons, *H. ceylanica* is washed ashore in the southern coasts, and the alga grows luxuriantly at Andaman and Nicobars coasts on rocks, exposed to surf.

HALYMENIA CEYLANICA Harv.
(× 0.75)

ENANTIOCLADIA PROLIFERA (Grev.) Falkenb.

Plants in small clusters, growing together, attached to rocks by a basal system. *Frond*, flat, dark red or deeply dark in older portions, firm, robust; in other portions, thin and light red. *Main branches*, broadly linear, plano-compressed, 2-3 times pinnately divided, in opposite distichous manner. *Branches*, patent, almost horizontal below, becoming erect, patent above, with oppositely placed shoots arising from the edges of the flat thallus. *Shoots*, generally shorter, later becoming longer also. *Secondary branches*, proliferating from ventral side of frond. Branches of every order provided with teeth or hooked branchlets. *Trichoblasts*, in rows along dorsal side of branchlets, often irregular, about 100 μ high, with short cells and thick walls, forked a few times. *Procarps*, along median line of dorsal side of fertile branchlets, generally 1 for each branchlet, or 2-4, rarely more. *Cystocarps*, globular, sunken, with dense cortical layer, stalked, 600 μ in diameter. *Tetrasporangia*, in rows in branchlets of 3rd. order in stichidia. *Colour*, vine-red, deep red and becoming darker on drying. *Substance*, fleshly, membraneous. Plants do not adhere well to paper on drying, especially when old.

Habitat : Cape Comorin, on rocks; Tuticorin, in Pearl-beds; Dhanushkodi, washed ashore.

The red-alga illustrated here is an interesting sea-weed of our coast. At Cape Comorin, it is seen to grow on hard rocks, quite at the shore, and which are violently dashed by strong waves or washed by gushing currents. On such rocks, the growth of the alga is restricted to areas which are not exposed to direct sun light at all, the plants being seen on the lower faces of escarpments. At Tuticorin, it is seen to grow in deeper waters, in Pearl-beds. The older portions of the thallus are seen infested with heavy epiphytes of various kinds, while the younger portions, being quite free from them, are reddish with some-what glossy surface also. *Griffithsia* sp. is seen to be associated with *Enantiocladia* at Cape Comorin on the rocky ledges.

PLATE IV

ENANTIOCLADIA PROLIFERA (Grev.) Falkenb.
(× 0.75)

GRIFFITHSIA FLABELLIFORMIS Harv.

Plants erect, bushy, flabellate, jointed and bead-like, reaching as much as 10-15 cm high; regularly repeatedly dichotomously branched, 8 or more times. *Branches*, moniliform. *Lower parts of thallus*, patent, upper portions with closely set branches with acute angles. Joints in patent portions of frond cylindrical. *Segments* in the erect branches, strongly beaded, inflated in the middle portions of cells, 2-3 mm broad and 2 to 3 times as long as broad. Ultimate divisions taper to a point into a string of tiny beads. *Colour* fine red, turning to greenish to yellowish on exposure and desiccation. *Substance*, somewhat lubricious, gelatinous. Algae adhering to paper firmly on drying.

Habitat : Dwaraka, Okha Port; in protected situations; in rock-pools etc.; Dhanushkodi, Cast ashore.

The red-alga presented here grows luxuriantly in bushy forms, in well protected situations, which are cut off from direct insolation. They are seen to grow also underneath some of the larger forms which also incidentally afford the present alga some sort of protection. In escarpments, on the lower faces, the alga is to be searched for, for luxuriant growth. The moniliform and regularly branched thallus and its fine red colour render the alga somewhat attractive, although the plants themselves are not very conspicuous for their size.

PLATE V

GRIFFITHSIA FLABELLIFORMIS Harv.
(× 1)

POLYSIPHONIA VARIEGATA (Ag.) Zan.

Fronds, in dense tufts and bushes, caespitose, upto 10 cm-25 cm or more high, gradually attenuated upwards; fastened to substratum by numerous rhizoids from the decumbent creeping filaments. *Rhizoids*, not ramified, ending in irregularly lobed discs; 50 μ thick. *Peri-central-cells* six, in basal parts sometimes seven, and in upper parts five. *Cortical layer* present or absent. *Branches*, in axils of trichoblasts. Distance between branches large. *Tetrasporangia*, in the upper part of branches, in shorter or longer rows, small, imbedded. *Cystocarp*, broadly ovate, nearly spherical with short stalks. *Filaments of fronds*, much branched pseudo-dichotomous, lower axils patent, close together, upper more distant and less spreading. *Secondary branches*, virgate, zig-zag with dichotomous ramuli. *Ramuli*, flaccid, slender. *Colour* of lower part, greenish, of upper part especially at ramuli, more or less dark-purple or purplish brown. *Substance*, rigid below, flaccid and gelatinous above. Plants adhere well to paper on drying.

Habitat : On mud covered rocks, in bays and estuarine regions and on other marine plants; in lagoons in dirty water. Krusadai Is; Okha; Dwaraka.

POLYSIPHONIA VARIEGATA (Ag.) Zan.
(× 1)

DESMIA HORNEMANNI Lyngb.

Frond, in clumps, caespitose, rising from a small scutate basal disc. *Thallus*, 1/2 cm, usually much less, 4-5 times pinnately branched in disticho-alternate manner, subflabellately expanded, linear, compressed or a little thickened below, ecostated, 12 cm high, 1.2 mm broad. *Main branches*, irregularly alternate, rather naked below, with lower branches, usually longest, becoming gradually shorter above; branches of every order, in similar mode of ramification. *Margins*, furnished with sharp, often deltoid-obtuse, simple or divaricated teeth. *Branches*, all arising on round axils, patent, straight or rolled up at apices. *Glandular cells*, with yellowish contents beneath the cortex. *Tetraspores*, irregularly roundish, in nemathecia. *Nemathecia*, slightly elevated, arranged in rows along the margins or in the intra-marginal surfaces of branches. *Cystocarps*, like tetraspores in nemathecial positions. *Colour*, deep red to blood red. *Substance*, rigid, when fresh, soon, sub-gelatinous. Plants adhere firmly to paper on drying, giving beautiful herbaria.

Habitat : On rocks, between tide marks, nearer low water mark. Cape Comorin; Pamban; Krusadai; Tuticorin; Hare Is.; Okha; Dwaraka; Shingle Is.; Laccadives.

This beautiful red-alga is seen to flourish in depths, in very clear-water deep lagoons, at Laccadives, where the floor is purely sandy, and white or greyish in colour, with good penetration of sun-light. At Cape Comorin, it is seen to flourish on hard rocks, in clefts, and flat depressions at the top, which are filled with pure coarse sand, and the surface being frequently washed by wave action, thus the alga being wetted and exposed alternately.

DESMIA HORNEMANNI Lyngb.
(× 1)

ACANTHOPHORA DELILEI Lamour.

Plants, erect, cylindrical, tall, reaching a height of about 10-15 cm. *Spines* on main stem. *Rhizoids* attaching the plants to substratum. *Central axis*, surrounded by 5 pericentral cells, covered by soft tissue. *Cortex*, small celled, towards the surface. *Growing apex*, protruded a little often in apical groove. *Tetraspores*, in stichidial ramuli, spine-less, ovate and rounded. *Colour*, varying from dirty red to dark red. Plants adhere to paper on drying.

Habitat : Below low water mark; in exposed and sheltered places; Okha, Dwaraka, Bombay, Tuticorin, Hare Is.; Pamban.

The alga presented here is a denizen of the low and shallow water areas in the intertidal belts along our coasts. During low tide also, the water is upto ankle or knee deep in the situations where this alga is seen to grow luxuriantly, and covering a large floor area in these places. They occur in larger or smaller groups, amidst other larger sea-weeds, and more towards the lower limits of the low water mark.

ACANTHOPHORA DELILEI Lamour.
(× 1)

LAURENCIA PEDICULARIOIDES Boergs.

Frond, usually upto 15 cm or more tall, flat, 3-4 cm broad, 1 mm thick, dichotomously, pinnately branched. *Branches*, irregularly revolute. *Pinnae*, usually about 3 mm long, sometimes upto 1/2 cm or more long. *Basal portions*, narrow, towards apex broader, undivided, wide, rounded, and divided into 2-3 lobes. *In section*, peripheral cells roundish, polygonal. Cells of Medullary layer with thick walls. Lenticular thickenings not quite evident. *Tetrasporangia*, formed in older parts of thallus, on upper parts of pinnae, globose, very large, about 120 μ across. *Colour*, in older parts dark red, and younger parts fine rosy red. *Substance*, horny. On drying, alga adheres firmly to paper.

Habitat : Dwaraka, near low water mark.

PLATE IX

LAURENCIA PEDICULARIOIDES Boergs.
(× 1)

PORPHYRA TENERA Kjellm.

Plants, membranous, attached to substratum by a small hold-fast. *Hold-fast*, with spreading rhizoid-like structures, from lower cells of the thallus, forming a compact cushion. *Rhizoid* unicellular, some being branched, adhering to substratum by gelatinous walls and suckers from lower ends. *Thallus*, thin, expanding above into soft, slippery blade of varying width. *Blade*, elongated, linear, with broad bases, often unbranched, reaching a length of about 25 cm or more. *Margin*, sinuate, undulate. *Structure of thallus*, one or two cells thick, cells elongated perpendicular to surface with strong cuticle. Asexual reproduction by monospores. Sexual reproduction by spermatia and carpogonia. *Spermatia*, at apex or edges of blades, spreading towards base, as many minute cells arranged in several layers by repeated division of the thallus cells. *Carpogonia*, simple, formed by vegetative cells, protruding. Fertilisation giving rise to cluster of carpospores. *Colour* dull purplish, brownish purplish or greyish purplish. Plants adhere firmly to paper on drying.

Habitat : On rocks, between tide marks, or on rocks nearer shore, constantly bathed by waves or submerged. Cape Comorin; Madras Harbour.

The red-alga presented here at the right hand bottom of the plate, is the Indian representative, while the larger one is from Japanese coasts. In India *Porphyra tenera* is seen to grow on isolated rocks, and boulders in small numbers, in situations which are well exposed and the rocks and boulders being only washed by the overthrow of sea-water due to wave action, or submerged by the swell and rise of water level during tidal and wave actions. The plants get often completely exposed to sun during low tides, and they show remarkable capacity to withstand desiccation, reviving rapidly with the advent of the high tides. *Porphyra tenera* is the "Nori" of Japan. Popularly called the Red Laver, it is extensively cultivated in coastal towns in Japan and is one of the most important branches of Sea-weed Industry in that country. Tokyo Bay and Hiroshima are famous places for cultivation of *Porphyra*.

PLATE X

PORPHYRA TENERA Kjellm.
(× 0.75)

AMPHIROA ANCEPS (Lamk.) Decsne.

Plants occurring in large tufts and bunches, rigid, coralline, with marked calcification, flexible. *Basal part*, usually a small disc, bearing erect fronds. *Fronds*, branched dichotomously at top of broadened joint, rarely trichotomously. *Adventitious branches*, from joints. *Joints* flattened, two-edged, sometimes cylindrical, also much flattened, with broadened portions. *Upper joints* always flattened. *Top joints*, fan-shaped, distinctly zonate. *Central strand*, 2-4 or 5 rows of long cells, followed by very short cells, 12-20 μ. *Cortical layer*, thin. *Conceptacles*, on one side of joint, occasionally on both sides of fertile branch, slightly prominant, 250-410 μ in diameter. *Tetraspores* and *antheridia* in conceptacles. *Colour* variable, light coral-red usually. On drying to exposure, bleached to white to light red. *Substance* hard, fragile. The plants on drying do not adhere to paper.

Habitat : Cape Comorin; Krusadai; Bombay; Okha; Dwaraka; Karachi (Pakistan). Between tidal levels and deeper waters; also dredged. Abundant along our shores in lagoons on reefs, in sheltered locations also.

The red-alga is very commonly to be seen cast ashore on the beach, and in varying conditions of desiccation. The completely bleached specimens are whitish, and fragile, crumpling and breaking off at joints easily. Small epiphytes are to be seen on the hard calcareous fronds. Fresh specimens are light and coral red, occurring in clumps.

PLATE XI

AMPHIROA ANCEPS (Lamk.) Decsne.
(× 1)

GRATELOUPIA COMORINII Boergs.

Plants attached to substratum by a very minute basal disc. *Disc* continued up, to form a short stipe, upto 0.5 mm long, occasionally slightly more. *Frond* large, forming leaf-like expansions, thin, mucilaginous to feel, single or to four or more blades from the common disc, each separate with short stipes of their own; oblong elongated, reaching to 30 cm long and 6 cm broad at the broadest part. Size of frond quite variable from 14 cm long and from 5-6 cm broad or even up to 12 cm broad. *Base of frond* cuneate generally broadening out at the middle upper part and tapering towards the apical portions. *Apex* generally acute to acuminate. *Margin of frond* sinuate, very undulating, generally entire, but also with proliferations. *Proliferations* when present ellipsoidal in outline, elongated with broader bases and tapering ends and acute apex; variable in size, upto 2 cm long and 1/2 cm broad. In section, frond upto 400 μ thick. *Inner medulla* large of loose interwoven filaments. *Inner medullary filaments* 5-9 μ in diameter, interspersed with rhizoids, 3-5 μ in diameter. *Stellate cells* 15-20μ in diameter and *arms of stellate cells* upto 60 μ long. *Outer medulla* compact, cells irregular, 15-20 μ in diameter. *Cortex* of two distinct regions, inner and outer, many layered. *Sporangia* scattered over the thallus in the cortical layer and in the older parts of the thallus; cruciately divided. *Tetrasporangium* ovoid to ellipsoid, 25-30 μ long and 12-16 μ broad. *Cystocarp* sub-globose upto 200 μ in diameter and 100-125 μ thick, sunk in the thallus. *Colour* when fresh purple, and when old and battered and weathered purple with dirty greenish spots at basal parts of the lamina. Plant adheres very well to paper.

Habitat : Cape Comorin, in somewhat protected situations and not exposed to direct insolation, on rocks with fierce gush of sea-water during tidal and wave swells, and overthrow of water; also washed ashore.

The alga represented here is seen to grow luxuriantly at the interstices of huge rocks and attached to the rock-sides, through the gaps of which rocky situations, sea-water rushes with great force due to tidal and wave actions. With the advance and retreat of the water in such situations, the alga is violently agitated, being wafted this way and that way. But because of its more or less slippery nature of the thallus, and the thin laminated blades, and by virtue of its firm holdfast, it is able to withstand the turbulent sea. Though not occurring in large numbers in any particular situation, it is conspicuous where it grows, although collection may prove a bit difficult and somewhat risky. Specimens which are somewhat damaged have their thallus shapes variable; the apical portions are also in such cases truncated, becoming very broad. They also bear quite a number of proliferations from the margins, obviously rejuvenating portions of the thallus in the next favourable season.

GRATELOUPIA COMORINII Boergs.
(× 0.75)

GRATELOUPIA FILICINA (Wulfen) C. Ag.

Plants, tufted, gregarious, usually 5-6 cm or 12 cm, and upto 25 cm tall, apparently varying in form according to conditions. *Hold-fast*, flat. *Frond*, numerous, flexuous, linear, attenuated at both ends, usually pinnately branched at base, rarely single, often naked at apices, sometimes slightly bifurcated at tips, flattened in middle, 2-3 mm or 4 mm broad, nearer tips, subcylindrical, 1 mm across. *Branches*, distichous, horizontal, long, linear, tapering towards apex, ending in acuminate or sharp point, 1-2 mm in diameter, often bearing a second series of pinnate branchlets. Branches and branchlets, irregular or unilateral, scattered or close together or clustered. *Margin of frond*, and branches and branchlets, with acute proliferations. *Structure*, with moderately close filamentous central medulla. *Cortex* made up of anticlinal cell-rows. *Tetraspores* immersed in branchlets, crowded, oval, cruciate, formed in moniliform cells of outer layer, scattered over the whole thallus. *Cystocarp*, discoid, several, embedded in thallus, close together. *Colour*, dull purplish below, dark violet or blackish green, yellowish green at tips, transparent, glossy. *Substance*, firm below, above fleshy, cartilaginous, lubricious tender and soft. Plants adhere firmly to paper on drying.

Habitat : Madras harbour; Mahabalipuram; Bombay; Chilka; on rocks and boulders, on vertical faces, exposed to strong waves; in shallow waters, on exposed coasts, between tide marks.

The red-alga illustrated here is a very interesting member of the algal communities in exposed situations, where it grows in larger numbers, several in large tufts. The glossy, and somewhat firm and cartilaginous and slippery nature of the thallus enables the alga to withstand exposure and strong surf, even when directly acting on the alga. Three forms are recognisable in India. In *Grateloupia filicina* f. *horrida*, thallus is flat upto 1/2 cm broad, and along the margins, numerous unilaterally placed dense proliferations are seen. In f. *pectinata*, the thallus is 1 mm broad, numerous, narrow almost linear flat proliferations at edges of the thallus is seen. In f. *cirrhosa*, irregular ramifications are noticed, with numerous proliferations, and branches and branchlets from main filaments. In many cases, the branchlets end in tendril like structures. But anatomically all the forms have the same structure more or less. Periphery is with cortical layer of densely placed cells, which increase in size down below inwards. Middle tissue is composed of stellate cells, with very long arms, between which rhizoids run. The various forms are seen to flourish in different conditions, in sheltered areas, or in exposed situations.

GRATELOUPIA FILICINA (Wulfen) C. Ag.
(× 0.8)

GRACILARIA FERGUSONII J. Ag.

Plants in dense tufts, upto 6-7 cm or more high. *Basal hold-fast*, flat, expanded, disc-like, giving off young and old shoots intermingled. *Thallus*, terete, here and there somewhat narrowed. *Lower part of thallus* about 2¼ mm thick, tapering slowly upwards to 1½ mm at upper ends. *Apices of branches*, broadly rounded. *Ramifications*, generally at about half the height of erect shoots. *Younger shoots* upto this height, un-branched. At place of ramifications, shoots divide into 2 or 3 branches, pseudo-dichotomous several times, and almost in a same plane, branching shorter upwards. *Transverse section*, in medullary layer, cells rather small, about 80 μ broad, with thick walls. Cells in this layer of same size upto periphery. *Peripheral cells*, smaller, oblong. *Cortical layer*, with small cells, covered with thick cuticle. Alga adheres to paper.

Habitat : Tuticorin; Cape Comorin; Krusadai Is.; Shingle Is.; in rather exposed situations.

The *Gracilaria* figured in this plate, though not very common, is, however, seen to be in good numbers where they grow. Sometimes, the alga is washed ashore along with other larger algae. The habit of the alga clearly enables it to be distinguished in the field.

PLATE XIV

GRACILARIA FERGUSONII J. Ag.
(× 1)

GRACILARIA VERRUCOSA (Huds.) Papenfuss

Fronds, several, from a small disc-like hold-fast, filiform, cylindrical, flexuose, 5-20 cm or more long, about 1 mm thick, reaching upto 2 mm thickness, branched. *Branches*, lateral, very variable in length, ramifications, and thickness, mostly elongated, tapering towards apex. *Branchlets*, shorter, bearing simple ramuli, alternate. *Tetraspores*, densely scattered over the surface of the frond. *Cystocarps*, abundant, produced on all sides of branches, aggregated, hemispherical. In section, thallus with large roundish, thick-walled cells. *Colour*, purplish brown or yellowish, becoming blacker on drying. *Substance*, cartilaginous. The alga adheres well to paper on drying.

Habitat : Krusadai Is; Tuticorin; Chilka lake in Orissa. On rocks, stones, shells etc.

This red-alga is a very important economic species. According to the statistics available from the Director of Fisheries, Orissa, about 5 tons of dried *Gracilaria* weeds can be gathered from Chilka lake per year, fetching about Rs. 2,250/- approximately from these weeds. Of the sea-weeds harvested in Chilka Lake, *Gracilaria verrucosa* is the important, and this alga is known to grow in profusion at several places in the lakes, such as Pathara, Rhamba, Kalijai, Kholikote, Parikud, Kalijageswar and Nairi. However, not much of commercial use is known of these sea-weeds in India.

GRACILARIA VERRUCOSA (Huds.) Papenfuss
(× 0.75)

GRACILARIA PYGMAEA Boergs.

Plants small, occurring in low tufts, attached to substratum by a small thin disc. *Thallus* upto 4 cm high, sometimes reaching up to 5-10 cm and 2-4 mm wide; sub-cartilaginous, somewhat fastigiate, flat and irregularly divided from near base. *Branches* arising from the edges of flat thallus, alternate or 2-3 seriate from the same side. Thickness of thallus about 400 μ. *Section of thallus* with large medullary tissue of large rounded cells, surrounded by a thin layer of small cortical cells. *Medullary cells* 100-250 μ across. *Cystocarps* distinct, profusely scattered on the flat surface of the thallus, semi-spherical and somewhat protruding. *Spores* spherical. *Colour* of alga dull purplish red, fading with age and exposure. Alga adheres well to paper on drying.

Habitat : Krusadai Is., in intertidal lagoons and reef-faces, attached to coralline substrates; Karachi (Pakistan).

PLATE XVI

GRACILARIA PYGMAEA Boergs.
(× 1)

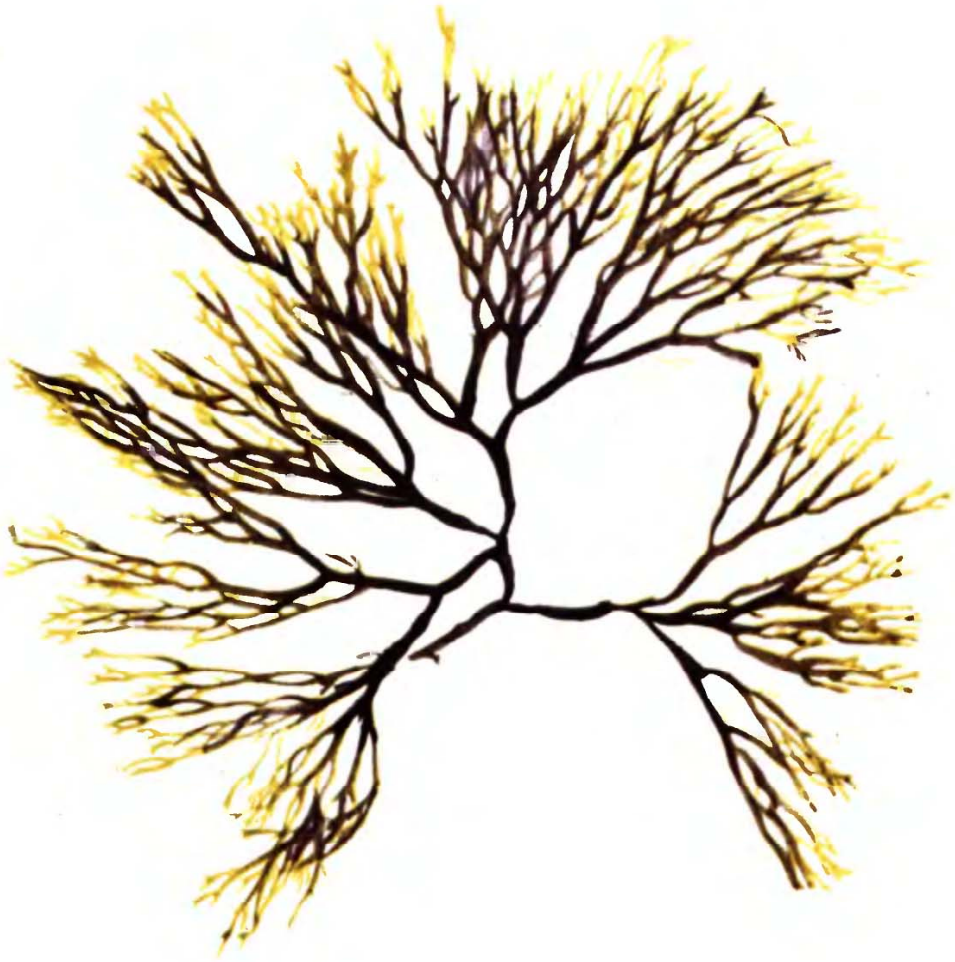
GRACILARIA CORTICATA J. Ag.

Plants growing in dense tufts, several growing together from a firm and hard hold-fast on rocky substrata. *Thallus* reaching 10-15 cm high, rigid, cartilaginous for greater part except for the extremities of the ramuli, repeatedly branched somewhat di-or tri-partite; width of segments 1-2 mm or 2-3 mm; in some cases even upto 3-4 mm. *Apices of segments* acute or obtuse. Some plants, however, having narrow almost linear thallus, tapering a little towards extremities, regularly and sub-dichotomously divided or irregularly divided with cuneate elongated segments. Thickness of frond more or less uniform. In section, *cortex* with densely packed cells; cells 6-10 μ in diameter. Central portion with large rounded oblong cells, surrounded by cortical cells. *Cells* in central portion 170-200 μ in diameter. *Cystocarps* large, sessile, globular or subovate with subacute apex. *Spores* globular or oblong, 20-26 μ in diameter. *Colour* when fresh, dark red, somewhat shining and with age becoming darker and violet red. Plants partially adhere to paper on drying.

Habitat : On exposed hard and rocky substrates with direct wave action. Cape Comorin; Kovalam; Quilon; Tuticorin; Hare Is., Madras Harbour; Mahabalipuram; Karwar; Bombay in Malabar Hill, Koloba, Back Bay, Bandra; Karachi (Pakistan) and Ceylon. Also cast ashore and drifted and stranded on the shore.

The red-alga illustrated here is a dominant member of the algal community in the intertidal zones and a little lower, as well as on rocky faces constantly washed by violent breakers in many places along our coasts. One variety of this alga, *Gracilaria corticata* J. Ag. var. *ramalinoides* J. Ag. grows in Bombay area. In some of the plants of *Gracilaria corticata* proliferations are seen given off from the apices of ramuli. At Mahabalipuram, near Madras, this alga with *Grateloupia lithophila* Boergs. forms a characteristic ecological zone, with the associated species as *Hypnea valentiae* (Turn.) Mont., *Bryocladia thwaitsii* (Harv.) De Toni, *Liagora erecta* Zeh, *Chnoospora fastigiata* J. Ag., and *Jania* sp. Although the alga grows in these situations throughout the year, its luxuriant growth was, however, noticed during the cooler months of January and February. By April, while the alga disappeared from places not constantly washed by the waves, it still continued to grow on rocks which were well far into the sea. After April, heavy growth of some polyzoons were seen on a large number of plants, and spreading over the entire thallus of *Gracilaria*. Epiphytes also came up in plenty with germlings of *Cladophora*, several species of *Ectocarpus*, such as *E. mitchellae* Harv., *E. duchassaingianus* Grun., *E. breviarticulatus* J. Ag., *E. thyrsoideus* Boergs. etc. An interesting green-alga *Pilinia* also grows as epiphytes, sometimes spreading over the entire thallus of *Gracilaria corticata* and giving it, more or less a bright green appearance. During summer months, *Gracilaria* disappear from many situations, only their sturdy firm hold-fasts remaining and by July the plants re-generate. The re-generated plants are quite free from epiphytes and have quite clean surfaces.

PLATE XVII



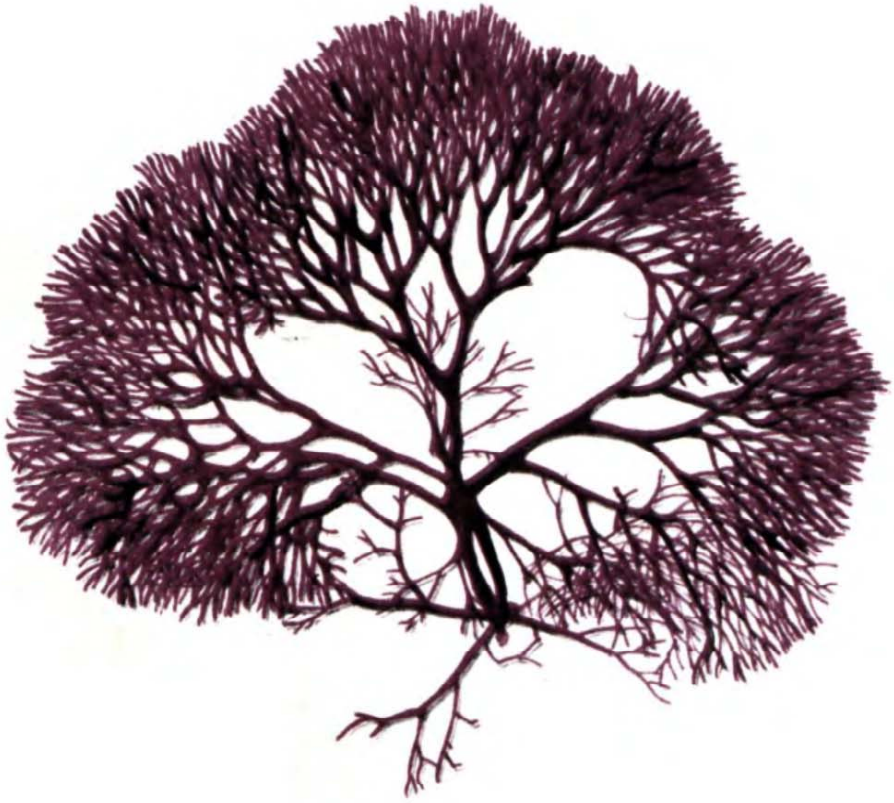
GRACILARIA CORTICATA J. Ag.
(× 0.67)

DERMONEMA FRAPPIERI (Mont. et Millard) Boergs.

Frond, short, coarse, erect, repeatedly branched, upto 4-10 cm height, firm in texture, upper ends, profusely branched. *Medulla*, loose. *Peripheral cells*, thick-walled, running longitudinally. *Carpogonial branch*, three celled with elongate gonimoblasts, extending horizontally through cortex. Vertical branch systems of gonimoblasts bear at end cells club-shaped carposporangia. *Colour* dark brown with tint of dirty red. Substance, firm, soft. The plant adheres well to paper on drying.

Habitat : On rocks, exposed to strong waves, Cape Comorin.

The red-alga presented here is capable of withstanding fierce direct wave action, and the thalli stand erect even when subjected to direct surf action. In the thallus of *Dermonema* from Cape Comorin an endophyte was described by Boergesen, *Ectocarpus dermonematis* Boergs., growing between the assimilating filaments of the host and quite immersed in the tough mucilage of the host.



DERMONEMA FRAPPIERI (Mont. et Millard) Boergs.
(× 1)

NEMACYSTUS DECIPIENS (Sur.) Kuck.

Plants, upto 30 cm or more long, very irregularly ramified, soft, slimy. *Frond*, filiform, often entangled, 3-4 times equally branched, alternate or dichotomous. *Central core of thallus*, colourless, densely covered with short assimilating filaments. *Assimilating filaments*, simple or branched, short, 1 mm thick at base, gradually narrowing upward; *branches and branchlets* very soft, pliable, diffused, flexuose in various directions, moniliform, bent upwards and filled with chromatophores. Above assimilating filaments, long colourless hairs protrude on all sides. *Cells* in the free end of assimilating filaments, cylindrical below, thin; above, cell thicker and swollen in the middle, about 20 μ or more across. *Unilocular sporangia*, oval to obovate, formed near the base of the assimilating filaments. *Plurilocular sporangia*, filiform, of one row of cells. *Colour*, dark olive brown; dried up specimens almost the same colour and a little greenish to yellowish brown. *Substance*, slimy. Plants on drying adhere very firmly to paper.

Habitat : On rocks and stones in very exposed locality, drying up during ebb tide for several hours. Dwaraka.

This alga forms loosely hanging filaments from the rocks on which they grow, exposed to direct wave action. They cover the surface of the rocks where they grow and making the rocks slippery thereby. In Japan, this alga is much used as food.

NEMACYSTUS DECIPIENS (Sur.) Kuck.
(× 1)

CHNOOSPORA FASTIGIATA J. Ag. var. **PACIFICA** J. Ag.

Plants in large tufts, gregarious, reaching a height of 10-13 cm. *Hold-fast*, disc-like, solid. *Frond*, wiry, filamentous, much ramified, branching irregularly dichotomous, expanded below forks, 2-4 mm wide, 1 mm thick, elsewhere about 1-2 mm thick. *Forkings* in acute angles. Throughout upper parts of plants, branches compressed. *Tips* acutely tapering. *Hairs* prominent, in tufts, emerging from barely indicated depressions. *Thallus in section*, of number of cell-layers, growing by apical meristem. *Plurilocular sporangia* in dense sori, aggregated around tufts of hairs. *Colour* dark brown below, and light brown above. *Substance*, wiry, firm, somewhat soft.

Habitat : On rocks, in intertidal belts on exposed surfaces. Cape Comorin ; in crevices, on very exposed localities, Seven Pagodas ; on rocks dashed by waves, Cape Comorin.

The plants growing in areas which are directly exposed to strong waves, are dwarfed and densely crowded. In other localities, where the wave action is not so fierce or severe, the plants reach considerable lengths.

PLATE XX

CHNOOSPORA FASTIGIATA J. Ag. var. PACIFICA J. Ag.
(× 0.5)

PADINA PAVONIA (L.) Lamour.

Plants tufted with perennial prostrate richly branched basal portion, forming a distinct hold-fast, attached to substratum by means of tufted rhizoids. *Fronds* erect, several arising from the base in each tuft, 5-12 cm high, cuneate, attenuate at base, broadly fan-shaped at upper portions, larger ones loosely rolled on their long axis, subentire or deeply lobed, each lobe about 2.5 cm or more in diameter. *Margin*, revolute, curved. *Concentric zones on fan* several. *Hairs* arranged in regular rows along the concentric zones. *Upper surface of fronds* smooth; *lower surface*, white with incrustations of lime. *Texture of frond*, thick and leathery below, membranous above. *Sporangia* ovate, yellow or red-olive, occurring along at every other row of hairs.

Habitat : At mid-tide levels, and in lagoons with fine sand or greyish silt, on dead corals; also on rocky surfaces washed by waves. Cape Comorin; Kovalam; Quilon; Mahabalipuram; Krusadai Is.; Rameswaram Is.; Shingle Is.; Tuticorin; Bombay; Waltair; Dwaraka; Okha; and in many places along our coast.

The brown alga with the other species of *Padina* is common along our coasts. Wherever the alga grows, it attracts attention by the characteristic cornet-like thallus, rolled among themselves, and several tufts occurring together to form distinct communities.

PADINA PAVONIA (L.) Lamour.
(× 1)

PADINA COMMERSONII Bory

Plants erect, in several clusters, arising from well defined hold-fasts. *Thallus* 12 cm or more in height, fan-shaped, *width of each lobe* at its widest upper most portion, 5-7 cm, differently cleft from the margin downwards to varying distances. *Thallus* in old specimens very often torn very irregularly, fan portions showing also variable pore-like areas due to dis-integration of thallus tissue. *Tetrasporangia and hairs* in alternating rows on the fan shaped frond, tetrasporangia being formed just above each row of hairs. *Indusium* absent. *In section*, thallus composed of a layer of small cells above and a layer of larger cells below. In older portions, cells become divided by horizontal walls into two cells, resulting in three layers of cells. *Colour*, dark brown on the upper surface, and white or ashy coated on the under surface. Plants adhere to paper on drying.

Habitat : Krusadai Is.; Okha; Dwaraka; Muldwaraka. In low lying rock pools, and lagoons in littoral zones, on somewhat exposed shores; also on rocks.

The-alga is seen in several cases, being infested with an encrusting red-alga, *Melobesia*. The *Melobesia* appear as variable specks and patches, spread over the thallus of *Padina*, and by coalescence of adjoining patches of *Melobesia*, sometimes, large surfaces of the *Padina* thallus is seen covered by light pink encrustation of the epiphyte.

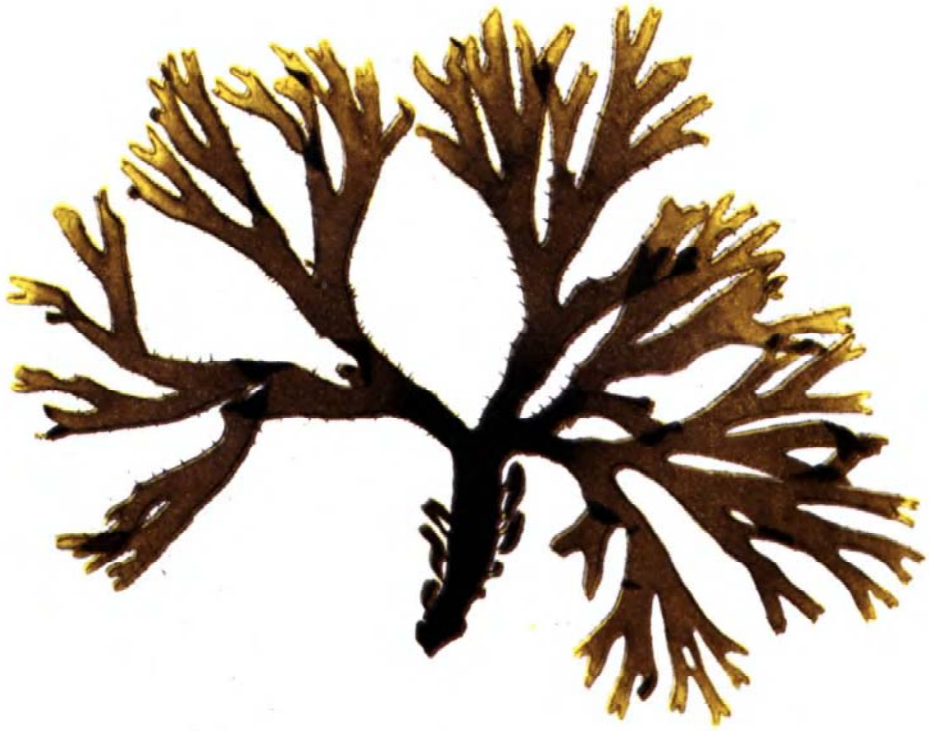
PADINA COMMERSONII Bory
(× 1)

DICTYOTA CILIATA J. Ag.

Plants in dense clumps, each plant arising from a disc-like basal hold-fast. *Thallus* 15 cm or more in height, dichotomously branched ; angles of dichotomy narrow, rounded to somewhat acute. Thallus lobes, flat, twisted. *Lobes*, 7-8 mm below and 3-5 mm in breadth above the forkings. *Margins* subentire to closely and minutely ciliate, *cilia* set apart at some distance from one another. *Proliferations* along margins in older parts, especially in plants growing in more sheltered areas. *Tetrasporangia* in scattered groups of sori on both sides of frond, 10 sporangia or more in each sori. *Oogonia* in spherical sori. *Antheridia* in large oval sori on both sides of thallus. *Antheridia* 50 μ long, 30-35 μ broad. *Colour* deep olive brown, turning to dark brown in older parts. Plants adhere well to paper.

Habitat : In muddy bottom in sheltered areas, in intertidal lagoons, amidst coralline reefs. Krusadai Is. ; Tuticorin; Hare Is.

The brown alga given here is a denizen of the inter-tidal belts, in lagoons with heavy muddy bottoms. Several clumps get sometimes detached from their anchor during heavy storms, and then during calmer low tides, they float or seen suspended in the body of water in amidst various other larger brown and green sea-weeds. They are also washed ashore and stranded on the beach.



DICTYOTA CILIATA J. Ag.
(× 0.67)

DICTYOTA DICHOTOMA (Huds.) Lamour. f. **IMPLEXA** (Lamour.) J. Ag.

Plants, 10-30 cm long, dichotomously branched forming larger or smaller tufts and entangled masses. *Frond*, very narrow, much branched, twisted and quite entangled, 1 mm wide, becoming narrower towards extremities. *Branches* more profuse towards upper reaches of fronds and narrow extremities. *Angles of dichotomies*, narrow, rounded. *Tips* of branches acute. *Margin*, entire. *Fructiferous structures*, on the middle of the thallus leaving a narrow sterile margin on both sides of it. *Colour*, brown in older parts and light brown at extremities. *Substance*, thin, membranous. The alga adheres to paper well on drying.

Habitat : Tuticorin : Hare Is. ; Dwaraka ; Okha.

DICTYOTA DICHOTOMA (Huds.) Lamour. f. IMPLEXA (Lamour.) J. Ag.
(× 1)

ZONARIA LATISSIMA Kütz.

Plant, 10 cm or more high, broad, flabelliform. *Main stem* with tufts of rhizoids. *Thallus*, deeply divided into several largerand smaller lobes. *Lobes* with attenuated, cuneate base, broadening abruptly high up. At middle, expanded to flabelliform frond, or sub-reniform, with varying width, about 4-5 cm or more broad. *Margin*,even, roundish. Surface, concentrically zonate, smooth. *Thallus in section*, of densely placed cell, rows ; *cells* twice as broad as long, excepting cortical cells. *Cortical cells* in two cell-rows, as long as broad. *Colour*, dark brown or yellowish brown. *Consistency*, firm, tough. *Substance*, thin, papery and brittle. Plant adheres firmly to paper on drying.

Habitat : Krusadai Is. ; Shingle Is. ; in lagoons in inter-tidal belts.

ZONARIA LATISSIMA Kutz.
(× 0.75)

SARGASSUM POLYCYSTUM C. Ag.

Plants, upto 50 cm or more high. *Basal part*, dense mass of elongated branched root-like rhizoids. *Primary branches*, several, erect, 10-15 cm long from base. *Stem*, fibrilar. Stem of primary branches and branchlets, rough, with short processes, giving the plant a muricated appearance. *Leaves*, ovate, oblong, narrow, lanceolate, obtuse or acute, remotely dentate, 2-2.5 cm below and 1-1.5 cm above, membranous, rigid. *Cryptostomata* scattered on both sides of mid-rib. *Receptacles*, in clusters in axils of leaves. *Vesicles*, minute, numerous, with prominant pores, borne on filiform stalks, 1-2 mm long. *Receptacles* in racemes, 6-12 mm long, filiform, elongated. *Colour*, dark in stem, and brown to dark brown in leaves. *Substance*, rough, rigid. Plants on drying adheres to paper.

Habitat : Pamban Is. ; Krusadai Is. ; Shingle Is. ; Rameswaram; in lagoons and rocks in sub-littoral belts.

SARGASSUM POLYCYSTUM C. Ag.
(× 1)

SARGASSUM SWARTZII (Turn.) C. Ag.

Plants reaching 60 cm or more. *Hold-fast*, disc-shaped, firm. *Primary axis* short, stout, giving off several erect branches. *Erect shoots*, coriaceous, plano-compressed, about 3 mm thick below, and 2 mm above. *Secondary branches*, at 2-3 cm apart from erect shoots; 8-12 cm long, bifarious, compressed below and cylindrical above. Secondary branches with very short branchlets, 4-5 cm long, bearing leaves, vesicles and fructifications. *Leaves*, alternate, at base 5-6 cm long, linear, acuminate at apex, with distinct midrib, serrulate with minute scattered teeth in the margin. *Stomata* scattered, few. Leaves above half the length of basal leaves, cylindrical, filiform, midrib, indistinct or absent. *Cryptostomata* along margins. Leaves with fructifications, very slender capillary. *Vesicles*, at base of leaves, vary, elliptical, apiculate, borne on flat midribbed petioles; 5-10 mm or more long. *Receptacles*, small, racemose or cymose clusters, oblong, linear, furcate, slightly flattened, dentate. *Male and female structures* in separate plants. *Colour*, olive green to black. *Substance*, cartilaginous, thin in vesicles; branches coriaceous. Plants do not adhere to paper.

Habitat : Cape Comorin; Krusadai Is.; Pamban Is.; Andaman Is.; Nicobar Is. Abundant on rocks dashed by waves.

SARGASSUM SWARTZII (Turn.) C. Ag.
(× 0.75)

SARGASSUM WIGHTII Grev

Root, expanded and disc-like. *Stem*, erect, several, generally undivided, 30-60 cm high or more. *Branches* several, distichous, at intervals of 1.5 cm or more. *Lower branches* several cm long, becoming gradually shorter above; more remote towards summit. *Fructiferous branches* short, distichous. *Leaves*, 2.5 cm to 5 cm or more long, narrow, lanceolate, tending also to linear lanceolate, equally attenuated at both extremeties, acute, entire or obscurely repando-dentate. *Nerve*, faint. *Pores*, few, scattered. *Vescicles*, elliptical, apiculate, on long dilated foliaceous stalks, 5 mm broad, 10 mm long; in young plants, arising from axils of cauline leaves; later, accompanying fructifications. *Receptacle*, axillary, filiform, compressed, much divided, cymose or tassel-like; dense. *Colour* dark olivaceous. Receptacles, black. *Substance*, slightly cartilaginous. Plant adheres to paper lightly.

Habitat : Krusadai Is.; Pamban Is.; Cape Comorin; Quilon; Port Blair, Andamans Is.; and in many places along Indian coasts.

The *Sargassum* species, illustrated here favours open situations, on rocks which are dashed by waves or on coral-rocks exposed to severe wave action. The older portions of the old leaves, nearer basal parts, show heavy epiphytic forms, forming crustaceous expansions, which are thick and somewhat dirty white.

SARGASSUM WIGHTII Grev.
(× 0.5)

SARGASSUM DUPLICATUM J. Ag.

Basal hold-fast, a strong disc-like structure. *Frond*, erect, growing in patches on rocks. *Stem*, filiform, elongated, even, smooth, terete at base, compressed above, 2-3 mm broad. *Branches*, alternate, widely separated, 2-3 to 7 cm or more apart. *Leaves*, obovate, spathulate, stipitate, 1-2.5 cm long, asymmetrical at base, lower margin, obliquely roundish and ascending; upper, sub-recurved, becoming sub-falcate. *Margin*, grossly dentate. *Midrib*, evanescent. *Substance*, coriaceous, when fresh. *Vesicles*, spherical, not many, 3-5 cm diameter. *Pedicel*, flat, short, slightly winged with cryptostomata. *Receptacle*, less densely aggregated, cymose, usually isolated, toothed or unarmed. *Colour*, yellowish brown. The plant adheres partially to paper.

Habitat : Port Blair, Andamans Is.; Minicoi Is.; Laccadive Is.

SARGASSUM DUPLICATUM J. Ag.
(× 1)

TURBINARIA ORNATA J. Ag.

Plants, large, attached to substratum by strong hold-fasts. *Hold-fast*, expanded, disc-like, with numerous strong long incurved root-like structures. *Fronds*, several, arising from the basal hold-fast, 50 cm or more high. *Stem*, filiform, flexuose, undivided, somewhat cylindrical, compressed. *Branches* in an irregular spiral manner, from base to apex of stem. Branches, simple, nearer basal part and at roots vicinity, generally longer than those at apex, about 7-8 cm or more long; branches, gradually becoming shorter above, giving the whole plant a sub-pyramidal outline. *Stem and branches*, naked at their bases, rough with remains of broken peduncles. Elsewhere, covered with vesicles and fructifications. *Vesicles* in compound petiole, triangular; angles, acute, slightly winged, toothed or nearly obsolete, hollow within, terminated by a triangular or cordate membrane, flat or convex, extending. *Margins*, with minute teeth. *Fructifications* on branches and petioles of vesicles, simple or forked, raceme-like. *Colour*, olive brown, becoming dark-red on drying. *Substance*, coriaceous, flexible, tough, and somewhat woody in stem. The plant on drying, does not adhere to paper.

Habitat : On rocks and coralline rocks and boulders, in intertidal belts nearer low water mark; Krusadai Is.; Pamban; Andamans Is.

This brown alga is seen often cast ashore or left in the lagoons, being brought from near low water mark or from deeper areas during monsoons. Its lax-branches and somewhat more sparsely arranged vesicles distinguish it from the other species of *Turbinaria* from our shores.

TURBINARIA ORNATA J. Ag.
(× 0.75)

CODIUM TOMENTOSUM (Hudson) Stack.

Plants solitary or gregarious in fairly large clumps attached to substratum by well defined basal hold-fast. *Hold-fast*, expanded velvetty encrustation, forming wide patches on the surface of rocks and other substratum. *Thallus*, erect, from 6 in. to 2 ft. in height, dichotomously branched, with or without lateral ramuli; *branches* terete, and somewhat flattened at dichotomies, frequently compressed, linear, obtuse. *Frond* covered with delicate hyaline horizontal filaments, soft and gelatinous. *Axis of thallus* of innumerable, inter-woven, irregularly branched filaments, with radiating, horizontal clavate ramuli. *Apices of ramuli* forming the surface of the frond. Utricles obovate, clavate, 100-150 μ, rarely 200 μ in diameter, about 5-8 times as long as broad. *Apex* obtuse, unarmed. *Apical wall* moderately thickened. *Gametangia*, ovoid or oblong or fusiform, on both sides of the ramuli, 100-120 μ in diameter, 500-650 μ long. *Colour* green to dark green, with ashy fluffy appearance. *Texture*, sponge like. Plants adhere to paper on drying.

Habitat : Krusadai Is.; Tuticorin Is.; Cape Comorin; and many other places along Indian Coasts.

This green alga is very spongy to feel, and large assemblages of them are often seen brought forth and ejected by the sea on the beach, along with huge masses of *Caulerpa racemosa* in Krusadai and other places. It is also seen growing attached to rocks which are exposed and dashed by waves. In Inter-tidal rock-pools, they are also seen at the sides, but well below the water level, the free ends of the dichotomously divided thallus being suspended in the body of water. It has wide distribution throughout Pacific Ocean, Arctic America and Asia, southern extreme of America, and through the Atlantic to Indian Ocean.

CODIUM TOMENTOSUM (Hudson) Stack.
(× 0.75)

CODIUM DWARKENSE Boergs.

Plants upto 16 cm or more high, with disc-like hold-fast. Several proliferations arising from the basal-disc, with main thallus. *Thallus*, terete, 2-3½ mm thick, or slightly broader, several times regularly dichotomously divided with distances of 2-3 cm or more between the divisions. *Angles of arms*, narrow. *Colour*, light greenish green. *Surface* finely dotted. *Vesicles* of two types, slender and broader; slender vesicles tapering much below the upper roundish apical ends. Broader vescicles, side walls nearly straight and parallel. *Size of vesicles*, 130 μ-450 μ broad, and 700 μ-900 μ long. *Apical ends of vesicles* much vaulted in slender ones—less so in broader vescicles, being quite flat or little depressed. *Wall in summit of slender vesicles* thick upto 22 μ, stratified. *In larger vesicles*, thin. *Filaments* in the interior of thallus 30-50 μ thick. *Hairs* present in moderate numbers. *Gametangia*, irregular, spindle shaped to sub-obovate, 250-350 μ long; 100-160 μ broad.

Habitat : Okha port.

The alga represented here is seen to grow in the inter-tidal pools, and along the deeper clefts in the rocky coast at Okha port, and for greater part of the low tides also, the plants remain submerged under water.

CODIUM DWARKENSE Boergs.
(× 0.5)

CODIUM IYENGARII Boergs.

Plants of medium size, 8-10 cm or more in height, attached to substratum by well developed hold-fast. *Hold-fast*, small, disc-like. *Thallus* erect, fastigiate, terete, regularly dichotomously divided; *branches* 3-4 mm in diameter, broader just below the dichotomies. Distance between dichotomies about 1 cm. *Vesicles* variable in shape, broadly clavate to pyriform to even barrel shaped. Size of vesicles equally varying from 150-800 μ broad and 700-1100 μ long. *Apical part of vesicles* vaulted or flat or depressed slightly. Apical wall of vesicle generally thin, rarely upto 8 μ thick. *Hairs* arising from upper sides of vesicles, few. *Central filaments* 50-70 μ in diameter. *Colour* dark-green to yellowish to grey green. Plants adhere well to paper on drying.

Habitat : Forming extensive growths in shallow waters. Okha; Dwaraka; Karachi (Pakistan).

The species of *Codium* illustrated here is named after late Prof. Iyengar by the late Danish Botanist, Dr. Boergesen, the type locality being from Karachi in Pakistan. The species grows several together to form more or less a dense algal vegetation in favourable situations, especially in the inter-tidal belts, where the plants get exposed during low tides. They are also seen to grow in small rock-pools and puddles, at their sides, and more towards the upper limits. These plants harbour a number of epiphytes, such as *Ceramium*, *Polysiphonia* etc. Associated with *Codium* are also seen *Liagora ceranoides*, *Halimeda* etc.

PLATE XXXIII

CODIUM IYENGARII Boergs.
(× 1)

UDOTEA INDICA A. & E. S. Gepp

Plants with a root-mass in a small tuft, anchored to the substratum. *Thallus* erect, about 12 cm or more in height, slightly calcified with distinct and long stipe. *Stipe* simple, 1-3½ cm long, terete, slender at its lower or basal part, about 1-2 mm thick; higher up nearer at its top portion about 4 mm, becoming flattened and transition to the flabellum above. *Flabellum* 6 cm or more in breadth. In young plants, flabellum fan-shaped in outline, broadly rounded above and with a cuneate base. In older plants, flabellum longitudinally folded up with numerous proliferations from the edge of flabellum, folded with deep incisions, rotundato-flabellate, orbicular, panduriform, obovate or irregular. *Margin of flabellum*, entire, lobed or lacerate. *Surface of flabellum*, smooth, transversely zonate with un-even surface. *Texture of flabellum*, with filaments intricately woven. *Filaments* upto 40 μ in diameter, radiating from the stipe to the margin, sub-parallel, sub-flexuose, congested, pluri-seriate, different layers crossing obliquely, dichotomous or inconspicuously branched, papillate. *Papillae* upto 120 μ long, numerous, unilateral, short, peltate or abruptly truncate, usually simple, sometimes bilobate, and borne on exposed surface of flabellum. *Filaments within frond*, devoid of papillae. Papillae adherent at edges forming a primitive cortex. *Colour* green with whitish, greyish tint on the surface. Plants do not adhere very well to paper when old.

Habitat : Krusadai Is.; Tuticorin; Okha; Dwaraka; Karachi (Pakistan).

This green alga is a very interesting member of the Reef-community, in somewhat flat open situations, with considerable tidal effects. The root-mass is well buried in the interstices of the reef-beds, formed of corals, where there is accumulation of sand and silt. It is also found in very shallow lagoons, occasionally, with another interesting alga, *Avrainvillea* in restricted spots at Krusadai Islands. During low tides, the alga is completely exposed to sun, without even being washed by the gushing waves. The flabellum in young forms, stand erect, and unaffected by the sun-light on exposure; in the larger ones, they lie over the floor of the sea-bed, the neighbouring growth of other sea-weeds, giving the plants a sort of a protection from temporary desiccation. The alga being seasonal, it can be seen only during the very favourable seasons of the year.

UDOTEA INDICA A. & E. S. Gepp.
(× 1)

UDOTEA FLABELLUM (Ell. & Sol.) Howe

Plants with distinct bulbous to elongate basal part formed by root-mass. *Stipe* simple upto 15 mm long and 5 mm thick, flattened above. *Frond* large, reaching 21 cm or more in height, very variable in external form, thickly calcified and with heavy incrustations. Stipe continued above into a sub-orbicular flabellum and with a cuneate base at first, simple; later repeatedly and irregularly proliferous from the margin, sometimes also from the surface of the flabellum. *Flabellum*, often striate or plicate, with distinct to indistinct zonations. *Proliferations* numerous, broad or narrow, overlapping, repeating the characteristics of the main frond; heavily calcified, smooth to rugose. *Margin* entire or more or less lobed. *Colour* varying from green to greenish white and to greenish brown. *Frond filaments* more or less parallel, radiating upwards, flexuous, pluriseriate and separated with sparingly disposed lateral branchlets of equal lengths at irregular intervals forming a sort of a cortical layer. Plants do not adhere well to paper on drying.

Habitat : In shallow inter-tidal, heavily silted lagoons with muddy bottoms. Hare Is., Tuticorin. Also in deeper waters upto 40 m on loose sandy bottoms.

This interesting green sea-weed is a typical denizen of loose-muddy bottomed shallow lagoons in situations which are more or less exposed, wherein the waves are constantly rolling behind coral reefs. The bulbous root-mass lies buried in the heavily silted, muddy or sandy sea-bottom. The alga is heavily laden with fine silt and quite a number of epiphytes grow on the much proliferated and lobed flabellum, among which are species of *Polysiphonia*, *Cladophora*, etc. *Melobesia* forms tiny circular encrustations on the older parts of the flabellum, more especially at the basal parts of the fronds. *Avrainvillea* is another very rare and interesting species to be seen associated with this alga in these situations at Hare Island, off Tuticorin. It is highly interesting that *Udotea flabellum* is widely distributed in the Tropical zones, occurring both in the Eastern and Western Hemispheres. The alga is very variable in its external form and as to its habitat, having been known from shallow waters in lagoons, and in deeper waters up to 30-40 m, but always growing in situations with loose sandy or muddy sea-floors only.

UDOTEA FLABELLUM (Ell. & Sol.) Howe.
(× 0. 75)

VALONIOPSIS PACHYNEMA (Martens) Boergs.

Plants, caespitose, in low dense tufts, forming larger or smaller cushions. *Haptera*, numerous, fastening the cushions to the rocks, vigorous, much irregularly ramified, some formed from branches higher up in the thallus; more usually from the basal ends of filaments of thallus. *Thallus*, with cylindrical ramified filaments, 600-700 μ thick. *Filaments* arranged mostly upward and vertical; others growing out in various directions, between the upward directed filaments, thus forming a sort of a felted cushion, upto 3-5 cm or more high. *Upper ends of filaments*, thicker, by division by walls forming cupola-like outgrowths on both sides of filaments ultimately forming short branches. *Branches*, not exactly opposite, but placed nearer to each other, on one side of the filament. *Branching* varies also, sometimes repeatedly branched, in unilateral series, umbelled. *Chromatophores* densely placed, below the wall layer, roundish, polygonal, with elongated corners, forming more or less coherent net. *Pyrenoids* single, large, sometimes two. *Wall layer*, thick, several layered. *Colour* green to dark green. Plant adheres to paper partially on drying.

Habitat : Krusadai Is.; Okha; Dwaraka.

This interesting green alga forms large, cushion like structures, attached to rocks between tide marks, and the upper littoral zones where sea-water is overthrown. The much branched and closely packed filamentous thallus ultimately lead to the cushion formation, and the individual branched filaments are easily separable. It occurs as somewhat large hemispherical cushions, and are also easily detached from the substratum.

VALONIOPSIS PACHYNEMA (Martens) Boergs.
(× 1)

DICTYOSPHAERIA CAVERNOSA (Forsk.) Boergs.

Plants, when young, globose, later forming expanded cartilaginous, membranous structures; hemispherical to sub-hemispherical and discoid, compressed. *Basal part* with longer or shorter root like prolongations. *Rhizoids* unicellular, many, from the lower most end and sides of root-like lower projections of the thallus. *Cell division of thallus*, seggregative; later becoming surrounded with membrane, cells close together and becoming arranged in same plane, resulting in a massive thallus; first sack-shaped; later, torn and disc shaped. Mature plants, disc shaped, very large, upto 12 cm in diameter. *Chromatophores*, roundish, polygonal, becoming connected with thin prolongations, forming a more or less open net work. *Pyrenoids*, large, 1-3. *Substance*, membranous, crisp and papery. *Colour* grass green to deep green. Plants adhere to paper somewhat.

Habitat : In shallow waters on often exposed coasts, growing on Coral reefs which are washed by waves. Also in deeper waters, dredged. Krusadai Is.; Shingle Is.; Okha; Dwaraka; Laccadive Is.

In some of the plants, walls of cells are densely covered with *Melobesia* which impart the alga a sort of light red tinge.

DICTYOSPHAERIA CAVERNOSA (Forsk.) Boergs.
(× 1)

HALIMEDA MACROLOBA Decsne.

Plants, erect, much branched and articulated, branching in one plane, reaching 10-16 cm high. *Roots*, bulbous, formed by a dense spongy mass of interwoven branching fibres, reaching a length of about 50 mm. *Articulations* immediately above root mass, short, much incrassated, thick, stalk-like, oblong or wedge shaped upwards, bearing on its expanded summit, one or more broadly cuneate articulations. *Articulations* in several successive series, ultimately forming a fan-shaped structure, distichous. *Shape and form of articulations* varying; broadly cuneate, roundish, oval, discoid, or reniform, sessile. Some of the mid-articulations either repand or somewhat obscurely lobed. *Margin*, thick, entire or irregularly lobed. Largest articulation, 20 mm high, 30 mm broad, 2-3 mm thick. *Lobes* thick, smooth, sometimes slightly glossy; surface heavily coated with carbonate of lime. *Peripheral cells* 30-40 μ across. In surface view, 75-150 μ long. *Colour*, pleasant yellowish green, fading to pale green or greenish white. In drying, plant does not adhere to paper.

Habitat : Andamans Is.; Nicobar Is.; Nancowry Is.

The large bulbous root mass penetrates deep into the somewhat slushy and muddy bottom of exposed coasts, which are coralline, with large expanses of shallow lagoons. Along with this alga, *Avrainvillea* species also grow luxuriantly, in Andaman Coast, especially at Long Island.

HALIMEDA MACROLOBA Decsne.
(× 0.75)

HALIMEDA TUNA (Ell. & Sol.) Lamour.

Plants about 10-20 cm high, moderately calcified, branched. *Branches*, in one plane, segmented. *Root*, small, somewhat bulbous. *Segments*, lower ones somewhat thicker, above thinner, thickness upto 1 mm. Segments varying in form, flat, discoid to elongate cuneate, not ribbed. *Margin* entire. *Size of segments*, 35 mm long, 22 mm broad. *Peripheral utricles* hexagonal in surface view 40-75 μ across, 75-100 μ long, adherent to some length, easily separable. *Utricles of subcortical layer* 35-110 μ diam. *Sporangia* globose to pyriform, 200-330 μ diam., deep green, borne on simple or forked pedicels on margin or surface of segments. *Colour* greenish when fresh and young, becoming chalk white with encrustations. *Substance* fragile, hard. Plant does not adhere to paper on drying.

Habitat : Attached to rocks in shallow waters, also in deeper waters; on sandy shallow pools; Pearl Banks, Gulf of Manaar; Krusadai; Shingle; Tuticorin; Cape Comorin; Okha; Dwaraka and several other areas.

Red encrusting epiphytic alga and several other minute filamentous red and green algae grow as epiphytes on the flat discoid segments of this sea-weed.

PLATE XXXIX

HALIMEDA TUNA (Ell. & Sol.) Lamour.
(× 1)

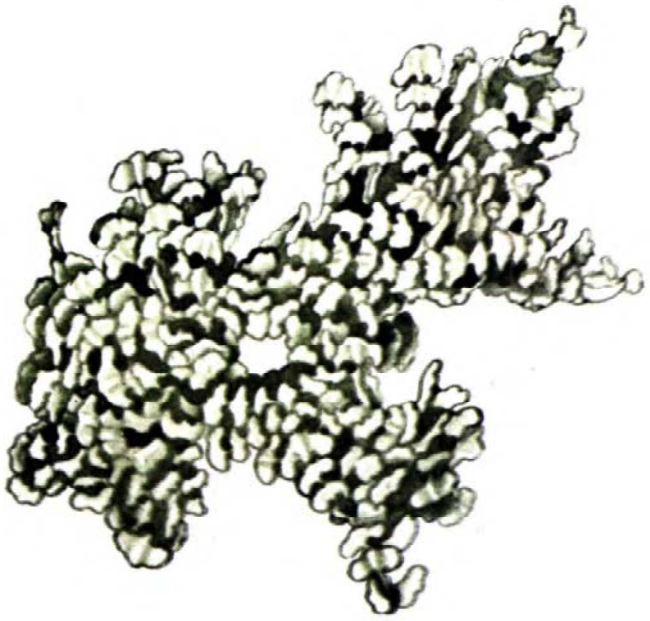
HALIMEDA OPUNTIA (L.) Lamour.

Plants to 10-25 cm long, varying in form, sparingly branched in one plane or in tufts with numerous radiating branches, with all intermediate forms. Fan structure of frond made up of number of flat, cordate or reniform, strongly calcified segments. *Segments*, sessile or stalked, cordate, discoid, trilobed or broad in middle and narrowed in both ends, ribbed. *Ribs* distinct or indistinct. *Size of segments*, to 12 mm long, 20 mm broad. Filaments in central strands, fusing in pairs at apex of each joint. *Peripheral cell*, 20-50 μ across; in surface view rarely 60 μ long. *Colour* when dry chalky white. *Substance*, fragile, loosely jointed. The plant does not adhere to paper on drying.

Habitat : Gulf of Manaar; Krusadai Is.; Shingle Is.; Rameswaram Is.; Pamban Is.; Cape Comorin; Kerala coasts; Bombay; Okha; Dwaraka; Andamans; in lagoons and pools at intertidal belts.

This species is perhaps the commonest and widely spread of our *Halimeda* species. It forms large tufts, and is frequently found in lagoons, and also washed ashore in quantities. Species of *Halimeda* are known to play a considerable role in formation of some coralline reefs, and the species are known from Tertiary onwards.

PLATE XL



HALIMEDA OPUNTIA (L.) Lamour.
(× 1)

CAULERPA PELTATA (Turn.) Lamour.

Plants with well developed stolons. *Stolon*, naked, horizontal, creeping over the substratum, robust or delicate, much branched, giving off rhizoids below and erect assimilators above. *Rhizoids*, cylindrical, delicate, colourless. *Erect axis*, vertical, varying from 1-10 cm in length, with numerous short branchlets. *Branchlets*, closely set, radiating in all directions, each branchlet terminating in a peltate assimilating disc, the *ramenta*. *Ramenta* pointing directly obliquely upwards, 3-8 mm across, more usually 3 mm or 2.5-4 mm in diameter. *Colour* light green. *Substance*, cartilaginous, ramuli and ramenta membranous, tough. Plant adheres partially well to paper on drying.

Habitat : In shallow rock pools on silt covered stones and coralline hard substrates; abundant in low tide pools; on rocky shores, on rocks near low tide marks. Krusadai Is.; Shingle Is.; Tuticorin and Hare Is.; Cape Comorin; Quilon; Bombay; Dwaraka; Okha; Andamans Is.; Laccadives Is. and many other places along our coasts.

The species of *Caulerpa* illustrated here, though not occurring in such huge quantities and masses as some of the other species along our coasts, is to be seen fairly well represented, though in very restricted situations and sparingly. On the coralline beds, along the sides of narrow and small creeks, which are silted heavily with fine white sand, this alga is seen in good numbers, though in small and tiny patches. On open surf-beaten rocky faces also, it grows, but always at situations well below water level and submerged. The plants in such situations are seen to be more robust, and the assimilators and peltate discs being larger and more greenish. The alga has a distribution over Indian Ocean, Red Sea, Pacific Ocean, occurring in places in the Eastern and Western Hemispheres.

CAULERPA PELTATA (Turn.) Lamour.
(Top fig. × 1: Bottom fig. × 8)

CAULERPA RACEMOSA (Forsk.) Weber-van-Bosse

Plants in larger or smaller groups, conspicuous. *Rhizome*, creeping, cylindrical, simple or divided and highly branched forming an intricate system. *Rhizoids*, from lower parts of prostrate rhizome, attaching plants to silt-covered stones, coral rocks and coralline pieces. *Erect branches* from upper sides of rhizome, irregularly scattered, 2-5 cm long or more, generally simple, terete, filiform and of uniform thickness, naked at base, higher up set up with ramuli. *Ramuli*, laxly placed, on all sides of erect branch, radial, erect or patent, pyriform, obovate or spherical, more or less laterally compressed. *Apices of ramuli*, entire or slightly emarginate. *Structure of thallus*, internally completely devoid of septation, with a central vacuole, with lining cytoplasm and chloroplasts. *Central cavity of thallus* with cylindrical skeletal strands, traversing in all parts, more strongly in rhizome, forming a radial system, and knotted in centre. In assimilators, strands irregularly displaced. In rhizoids, strands poorly developed. *Vegetative reproduction*, by fragments, common. *Colour*, grass green, turning on exposure to sun to yellow and then to white ultimately. *Substance* cartilaginous in stem; in ramuli, thin and membranous and flexible. Alga on drying adheres poorly to paper.

Habitat : Frequent in shallow rock-pools and lagoons protected by Coral reefs; on rocks, between tide marks in exposed regions, in sub-littoral belts; on sandy or muddy floors. Cape Comorin; Krusadai Is.; Shingle Is.; Pamban Is.; Tuticorin; Kovalam; Quilon; Karwar; Bombay; Okha; Dwaraka; Andhra Coasts; Andaman Is.; Laccadives Is.; and in many localities.

The species of *Caulerpa* illustrated here is very commonly to be seen in many localities along our coasts, in different situations and environmental conditions. Huge masses of the alga are often ejected by the sea and cast ashore near the high water mark, during monsoon months. In the meshes of the alga are also brought very many other interesting species from deeper areas, as such, search for some of the interesting forms which may not be possible to collect under normal circumstances, would result in profit. Quite a number of varieties and forms are distinguishable, dependent on the nature and arrangement of the ramuli and assimilators. Among the more common ones are, var. *clavifera* (Turn.) Web. v. Bosse, f. *typica*; var. *uvifera* (Turn.) Web. v. Bosse f. *condensata* (Kütz.) Web. v. Bosse; var. *laetevirens* (Mont.) Web. v. Bosse f. *typica* Web. v. Bosse and f. *laxa* (Grev.) Web. v. Bosse; var. *coryne-phora* (Mont.) Web. v. Bosse f. *complanata* Web. v. Bosse; var. *chemnetzia* etc.

CAULERPA RACEMOSA (Forsk.) Weber-van-Bosse
(Top fig. × 3: Bottom fig. × 5)

CAULERPA VERTICILLATA J. Ag. f. VERTICILLATA

Plants, tiny, in dense tufts, fastigiate, with well developed stolons. *Stolons*, creeping, branched, 490-700 μ in diameter, dark green; *branching of stolons* dichotomous or alternate, giving off rhizoids below here and there. *Rhizoids*, 800 μ long, 20-60 μ or 90 μ in diameter, dichotomously branched. *Erect axis* on the upper surfaces of stolons, 1.8-6.0-7.0 cm high, mostly 2.5-4.5 cm, profusely branched upto 3rd degree; *first branches*, spiral; later ones alternate or dichotomous, dark-green, 200-700 μ in diameter; ultimate branches and branchlets 33-140 μ in diameter, terminating in verticillate assimilators. *Assimilators* usually 0.5-2.0 cm, upto 2.5 cm in length; axis below naked, to 0.5-2.0 cm. *Glomerules of assimilator* dark green, turbinate, with straight or convex tips, 1.3 mm distant, 1.5-3.0 mm in diameter, about 4.0 mm high. *Glomerules* made up of 2-7 verticils of determinate branches; internodes of verticils telescoping; *determinate branchlets* 4-5 in a verticil, rarely 2 or 6, dichotomously branched, 4-8 times, usually 5-6 times, 2.5 mm in height ascending, cylindrical, soft; at bast 85-154 μ in diameter, with ultimate divisions 20-40 μ in diameter, not constricted at forkings. *Tips* blunt, simple with 2-4 rarely 5, obtuse erect, mucronate points, directed upwards.

Habitat : Tuticorin; Okha Port in Post Office reef, and Adithra reef.

This very interesting *Caulerpa* was first collected from Tuticorin for the Indian region, in April, 1875 and the specimen was included in the collections of Ferguson. The alga was reported for India from Tuticorin in 1906 by Svedelius. Prof. Iyengar and Prof. Desikachary have collected the alga for South India. F. Thivy and V. Visalakshmi reported this alga from Okha Port in 1963. According to Boergesen, the alga occurs only in very sheltered localities and lagoons in the Danish West Indies, while Svedelius reported this from Ceylon in open coasts. The alga is an interesting member of the mangrove belts, where it is seen attached to the roots of the mangroves and growing in tufts on them. The alga has its distribution in Bermuda, Florida, Mexico, W. Indies, Venezuela, Brazil, Ryukyu, Hainan, Siam, Indo-China, Philippines, Indonesia, Ceylon etc.

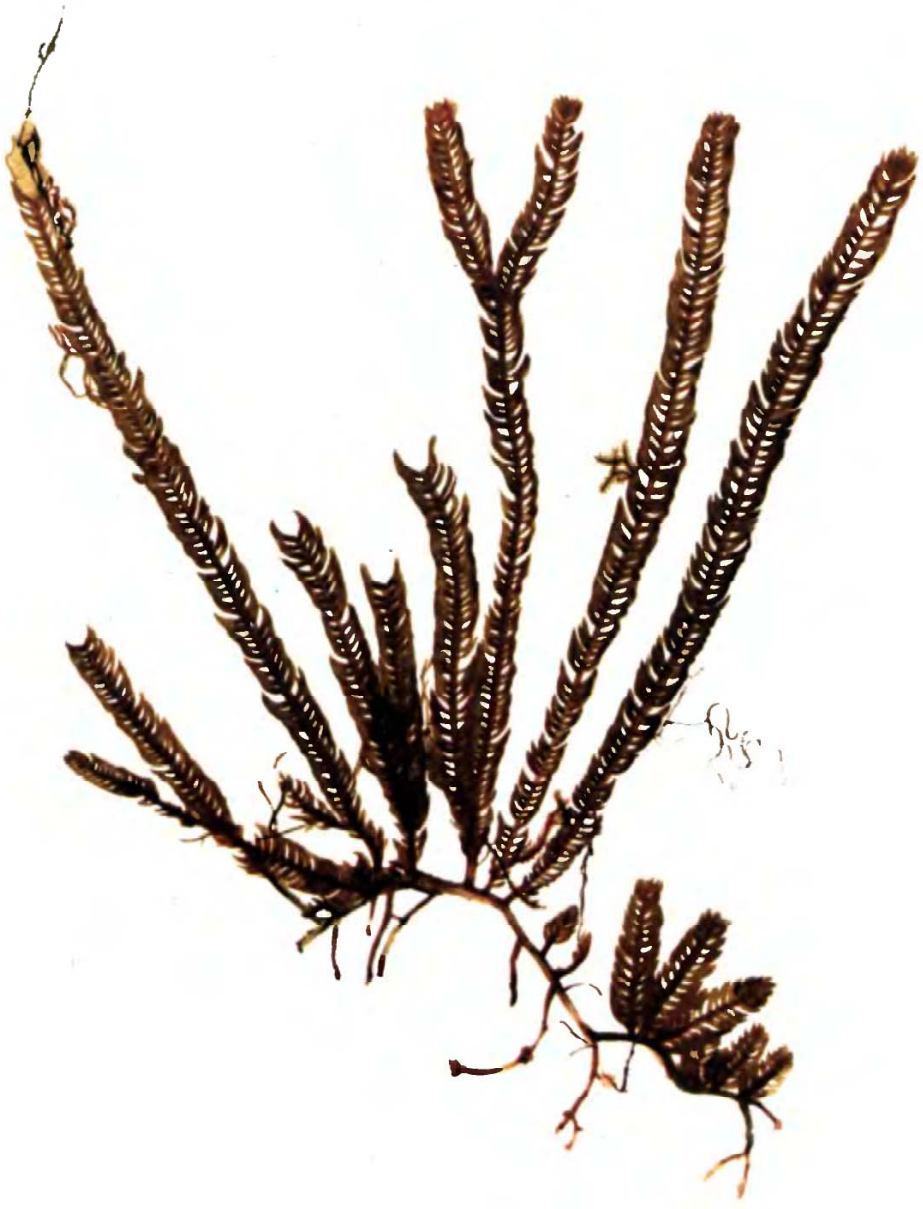
CAULERPA VERTICILLATA J. Ag. f. VERTICILLATA
(× 1)

CAULERPA TAXIFOLIA (Vahl) Ag.

Plants gregarious, growing in larger or smaller tufts on rocks, stones or creeping on muddy sea-floors of lagoons. *Stolon*, naked, creeping, several inches long, branched, 2 mm or more thick, rooting from the lower surface at intervals and with erect branches above. *Roots* deeply descending. *Fronds*, in one plane, lanceolate-linear, simple or branched, 20 -30 cm or more long. *Branches*, irregular, shorter than the main frond, but similar to the main frond. *Stipe* of frond, short, upto 5 mm long at base of frond, bare of pinnae. Above, rachis, 1-1.5 mm thick, closely pinnated upto the apex. *Pinnae*, opposite, erect, nearly equal, slightly constricted at base, lanceolate or sickle shaped, curved upwards, linear, acute, falcate, vertically flattened, ending in a short mucro, 1-1.5 mm wide, 4-8 mm long. *Colour*, yellowish green when fresh. *Surface* glossy. *Substance*, soft, membranous, or horny membranous. Plants adhere firmly to paper on drying.

Habitat : Pamban, Krusadai Is.; Okha Port; Karachi (Pakistan).

The alga described here grows in different habitats, in shallow waters, in quieter lagoons, or in exposed localities, or even in deeper waters, in Pearl Banks etc. Several forms are recognisable of this species, depending on the character of the frond. In desiccation, the tips of fronds and upper portions thereof, turn whitish and then they decay, proceeding from tip to the base of the frond. In partially decayed fronds, the tips of fronds appear truncated, with the terminally placed pinnae, strongly curved upwards.



CAULERPA TAXIFOLIA (Vahl) Ag.
(× 0.67)

CAULERPA CORYNEPHORA Montagne

Plants with a creeping, prostrate stolon, bearing at intervals, roots below, and erect assimilators above. *Stolon*, long, branched here and there, 1-1.5 mm thick, terete. *Rhizoids* thin, branched. *Assimilators*, vertical, flat axis, 5 cm or more high. *Ramuli*, in two opposite rows on the vertical flat axis; base of axis to 2-5 mm, naked, and above with regularly and closely set ramuli; width of ramuli, uniform, upto 1 mm wide, apices of ramuli, slightly wider. *Colour*, green to yellow green. *Substance*, rigid, and in the assimilators, somewhat membranous. Alga on drying, adheres well to paper.

Habitat : Tuticorin; Muldwaraka; Okha.

The *Caulerpa* species illustrated here is a very elegant form, and can be easily distinguished in the field by its characteristically arranged opposite rows of ramuli of equal width. It forms beautiful herbarium.

CAULERPA CORYNEPHORA Montagne
(× 0.75)

CAULERPA CUPRESSOIDES (Vahl) Weber-van-Bosse

Plants with a creeping stem, 10-12 cm or more long, cylindrical, filiform, naked, with roots below and erect shoots above. *Erect shoots*, 6-8 cm tall, richly ramified, densely crowded with branchlets, each branchlet ramified 3-6 times or more. Erect shoots, in some cases reaching as much as 10-15 cm, somewhat thinner than the stolon, divided or undivided. *Branches*, irregularly once, twice or upto 3-6 times forked especially at apices; smaller ramuli at apices. Branches, erect to patent, straight, short, at their bases, naked to some distance. Above beset with ramuli, closely imbricate in triple row, regular, tending to make every branch triangular, simple, patent. Apices of ramuli blunt or with minute mucro. *Colour*, pale yellow in root, stolon and lower part of branches; ramuli, grass green. On exposure, whole turns to white. *Substance*, cartilaginous, rigid, horny in stem and branches; in ramuli, membranous. On drying plant does not adhere to paper well.

Habitat : In varying localities and condition, in exposed coasts, behind coral-reefs; creeping on white coralline sand-beds in sheltered areas in lagoons; in muddy shallow waters and in deeper waters. Krusadai Is.; Pamban Is.; Tuticorin Is.

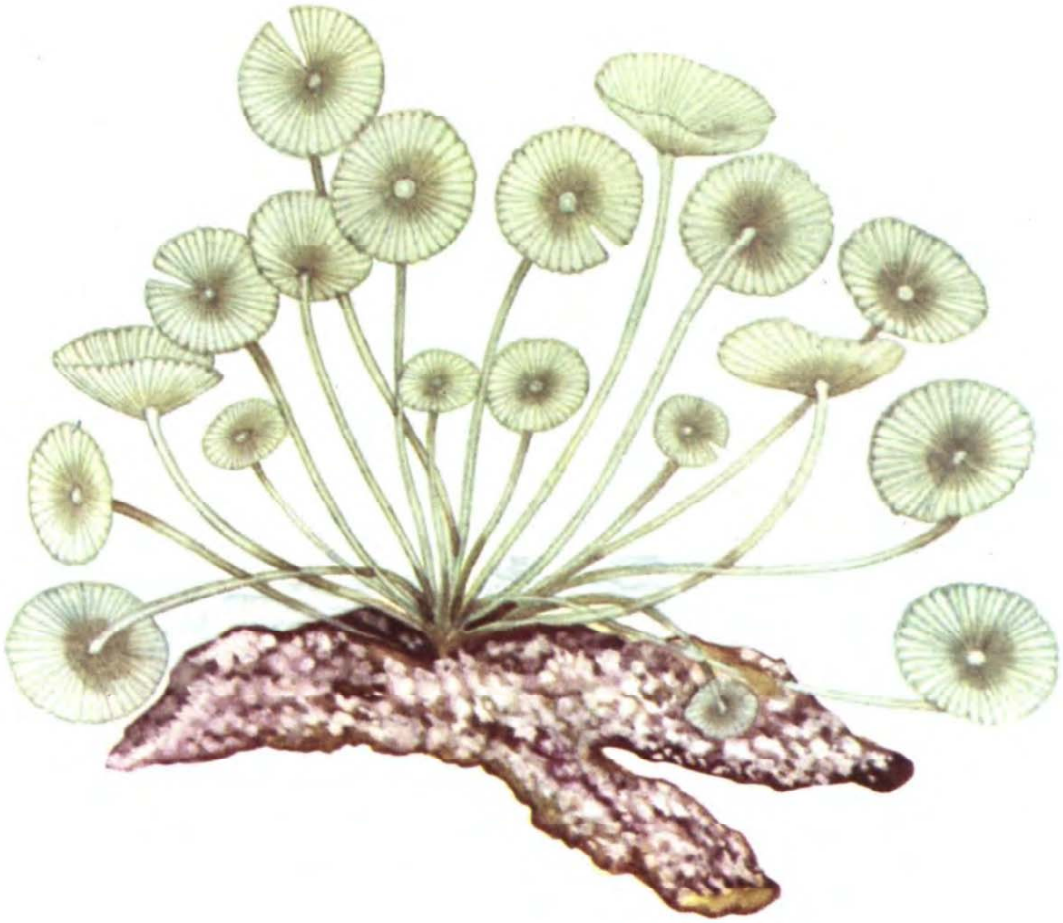
CAULERPA CUPRESSOIDES (Vahl). Weber-van-Bosse
(× 1)

ACETABULARIA CRENULATA Lamx. var. **MONODISCA** Boergs.

Plants growing in extensive patches attached to substratum. *Stipe*, filiform, upto 5 cm tall, bearing at its summit a disc. *Disc*, 1 cm to 1.5 cm in diameter, flat or slightly basin shaped. *Rays*, several, upto 60 in a disc, strongly calcified, united after decalcification. *Apex of rays*, broadly rounded, provided in the middle with a well developed apiculum. In some plants, apex little dpressed in the middle from which part the apiculum arises. *Superior Corona* segments, more or less emarginate, sometimes rounded. *Inferior Corona* segments, emarginate. *Hair-scars*, present, two in number. *Colour* : Chalky white on calcification. *Substance*, delicate in the disc, firm in the stipe. Plants adhere to paper poorly.

Habitat : Andamans, in the intertidal belts, on flat coralline beds, exposed to open sea.

The alga represented here popularly called as the Myrmaids Umbrella, is a beautiful and attractive member of the Chlorophyta. Quite large numbers of them, covering vast and extensive tracts are seen growing in thick and crowded patches. During low tide, the alga gets completely exposed and the umbrella lying in varying positions on the floor of the sea bed.



ACETABULARIA CRENULATA Lamx. var. MONODISCA Boergs.
(× 2)

BRYOPSIS PLUMOSA (Huds.) C. Ag. var. **PENNATA** (Lam.) Boergs.

Frond, erect, 4-7 cm high, forming thick tufts on rocky surfaces, sparsely branched, subsimple, above distichously plumose; ultimate branches linear lanceolate, plumose; pinnules, distichous, simple, gradually narrowed towards the base, grading rather evenly from the longest at base of the branch to the initials at the apex. *Colour*, yellowish green or olive green. *Substance*, soft, plumose. Alga adheres to paper on drying very fast.

Habitat : On rocks and stones, on exposed and sheltered areas; in inter-tidal rock pools; between mid-to low water mark. Muldwaraka.

The interesting *Bryopsis* represented here was growing in dense tufts on the sides of smaller or larger rock-pools, below water level and covered over by other larger sea-weeds also. It is a very elegant alga, especially in herbaria.

BRYOPSIS PLUMOSA (Huds.) C. Ag. var. PENNATA (Lam.) Boergs.
(× 1)

ULVA FASCIATA Delile

Frond, large, from 10-30 cm or more long, attached to substratum by circular or oblong hold-fasts. *Basal attachment disc* 2-4 mm in diameter. *Thallus* divided into many, more or less distinct, narrow lobes. *Lobes* 1-3 cm wide, flat, linear, lanceolate. *Margin*, undulate, or sinuate or irregularly dentate. *Transverse section of thallus*, thickness of segments at upper regions at margins 50-60 μ; at midrib, 70-90 μ; at base, thickness of margin, 60-90 μ; and midrib 110-115 μ. *Cells in surface view* polygonal with rounded angles, 18-22 μ in diameter, rarely 16 μ. In vertical section, cells slightly elongated. Chloroplast filling the outer half of cell only. *Colour*, light green, glossy, to dark green, fading with age. *Substance*, membranous, thin. On drying, plants adhere to paper.

Habitat : In rock pools, deeply submerged under water. Muldwaraka; in buoys, in Harbours, always submerged in sheltered places; Karachi (Pakistan).

PLATE XLIX

ULVA FASCIATA Delile
(× 0.5)

ENTEROMORPHA INTESTINALIS (L.) Link f. **CORNUCOPIAE** (Lyngb.) J. Ag.

Plants, solitary or gregarious, attached to substratum by a disc-like hold-fast; tufted, 1-6 cm or more long. *Frond*, mostly filamentous, tubular with few contortions, clavate, expanded above, compressed, simple or branched at base. Plants later in stage, detached and floating. New thalli arising from mature attaching discs. *Apices of fronds* perforated. *Cells*, irregularly arranged, polyhedral by mutual pressure, oblong or sometimes round, 10-16 μ long, 6-10 μ wide; rounded cells 8-16 μ in diameter. *Cells in transverse section*, oblong, 10 μ long, 8 μ wide. *Cell contents* granular. *Chloroplast*, parietal lying against the lower side of cells. *Cell wall* striated. *Colour*, deep green to yellowish green to grass green. Plants adhere firmly to paper on drying.

Habitat : Very common in many localities in India; in brackish waters, in littoral zones between tide-marks and in wide range of salinities; in places where there is pollution; abundantly growing on buoys in harbour areas; in very shallow brackish water lagoons and lakes, on mud banks or bottoms with sand or on rocks, Chilka Lake, Orissa; Madras Harbour; and many places in India.

The green alga presented in this plate grows gregariously in large numbers in Chilka Lake in Orissa in situations where the water is brackish. Associated with it are *Enteromorpha compressa*, and *Gracilaria verrucosa* in littoral zones between tide-marks. It also comes up in profusion where there is pollution, and where there are sewage confluence or discharge from factories etc.

ENTEROMORPHA INTESTINALIS (L.) Link f. CORNUCOPIAE (Lyngb.) J. Ag.
(× 1)

ENTEROMORPHA COMPRESSA (L.) Grev.

Plants, gregarious, attached to rocky substratum and coralline rocks and boulders. *Frond*, tubular, compressed, varying in dimensions, narrow at base, dilated above and at apex broadly rounded; 10-15 cm high. *Branches*, usually simple. *Cells*, small, 9-15 μ diameter, rounded, sub-quadrate, irregularly placed in adult plants. *Walls* not thickened. *Membrane* 15-20 μ thick. *Cells*, vertically elongate in transverse section. *Contents* filling the cells. *Pyrenoid*, single. *Colour*, bright to dark green. *Substance*, membranous. Plant adheres well to paper on drying.

Habitat : On rocks and coralline substrates, at and near high water mark. Krusadai Is.; Hare Is.; Madras Harbour; Mahabalipuram; Cape Comorin and in many localities.

This green alga is seen abundantly growing in coral reef-crevices and flat surfaces where there is a good accumulation of pure white sand, and more towards the high water mark. Along with this alga, in favourable places, *Boergesenia*, *Acetabularia* etc. also grow, particularly when the substratum is coralline with sandy patches in the depressions.

ENTEROMORPHA COMPRESSA (L.) Grev.
(× 0.75)

PHAEOPHILA DENDROIDES (Crouan) Batters

Plants microscopic; endophytic or epiphytic on other larger algae; filamentous. *Filaments* procumbent, usually uni-seriate, branched irregularly, becoming congested also. *Cells of filaments* broad, generally cylindrical, horizontally elongated, occasionally spherical or isodiametric or even quite irregular with sinuous walls; 7-40 μ in diameter and upto 50-80 μ or more long. *Lateral branches* arising from the main procumbent filament, also uni-seriate, few celled or single and globular or obovate. *Chromatophores* parietal, lobed. *Pyrenoids* several upto 12 or more in each cell. Some cells bearing hairs or setae, generally one to a cell or occasionally upto 3 to a cell. *Seta* hyaline, long, tubular, unseptate with distinctly firm and undulating walls, especially at basal part; *lumen of seta* continuous with the supporting cell, not separated by a wall; *basal part of seta* generally not swollen, occasionally wider than the portions above, about 6.6 μ or more across. Setae sometimes spirally twisted, 2.5-5.5 μ in diameter, 36-205 μ or more long. *Base of seta* with a slight collar like thickening. *Zoosporangia* on terminal branchlets, sub-cylindrical or irregularly swollen. *Zoospores* quadriflagellate.

Habitat : Endophytic in *Rosenvingea intricata* (J. Ag.) Boergs, Chilka Lake, Arkhakuda Sector, Orissa; on *Enhalus acoroides* leaves, in plenty; Pamban, Gulf of Manaar, S. India.

This interesting alga is reported from a number of localities along the Pacific and Atlantic Coasts of N. America, S. British Coasts and Adriatic Sea. For the Indian Ocean, it is reported from Mauritius and for the Indian region, it is known from Pamban in South India besides the Chilka Lake in Orissa, in N. India.

The alga appears to have a very wide range of hosts. Among the Spermatophytes, the host plants are *Zostera* sp. and *Enhalus acoroides*. Among the Green algal hosts, it is reported on *Cladophora*, *Chaetomorpha linum* (Müller) Kutzing and Codiaceae. Among the Rhodophyta, the hosts known are *Acanthophora spicifera* (Vahl) Boergs., *Champia parvula* (C. Ag.) Harv., *Chondria tenuissima* (Good. & Woodw.) Ag., *Chondrus crispus* (L.) Stackh., *Callithamnion*, *Gracilaria*, *Griffithsia*, *Hypnea*, *Laurencia obtusa* (Huds.) Lamx., *Polysiphonia flexicaulis* (Harv.) Collins, *Rhodymenia palmata* (L.) Grev., and Lithothamniae. It is also reported as growing on stones (at Mexico) which is an un-usual habitat for the alga.

The endophyte described here was detected in the tissues of a Brown alga, *Rosenvingea intricata* (Crouan) Balters from Chilka Lake. It was noticed in the older portions of the host thallus. In the early development of the endophyte, a somewhat large isodiametric cell with irregular shape and rich content is noticed. This, soon divides in different planes to result in a compact mass of cells within the host plant. Ultimately the thallus of the endophyte develops into a branching uni-seriate filamentous structure with large cells of variable shapes and sizes, and some cells bearing setae also.

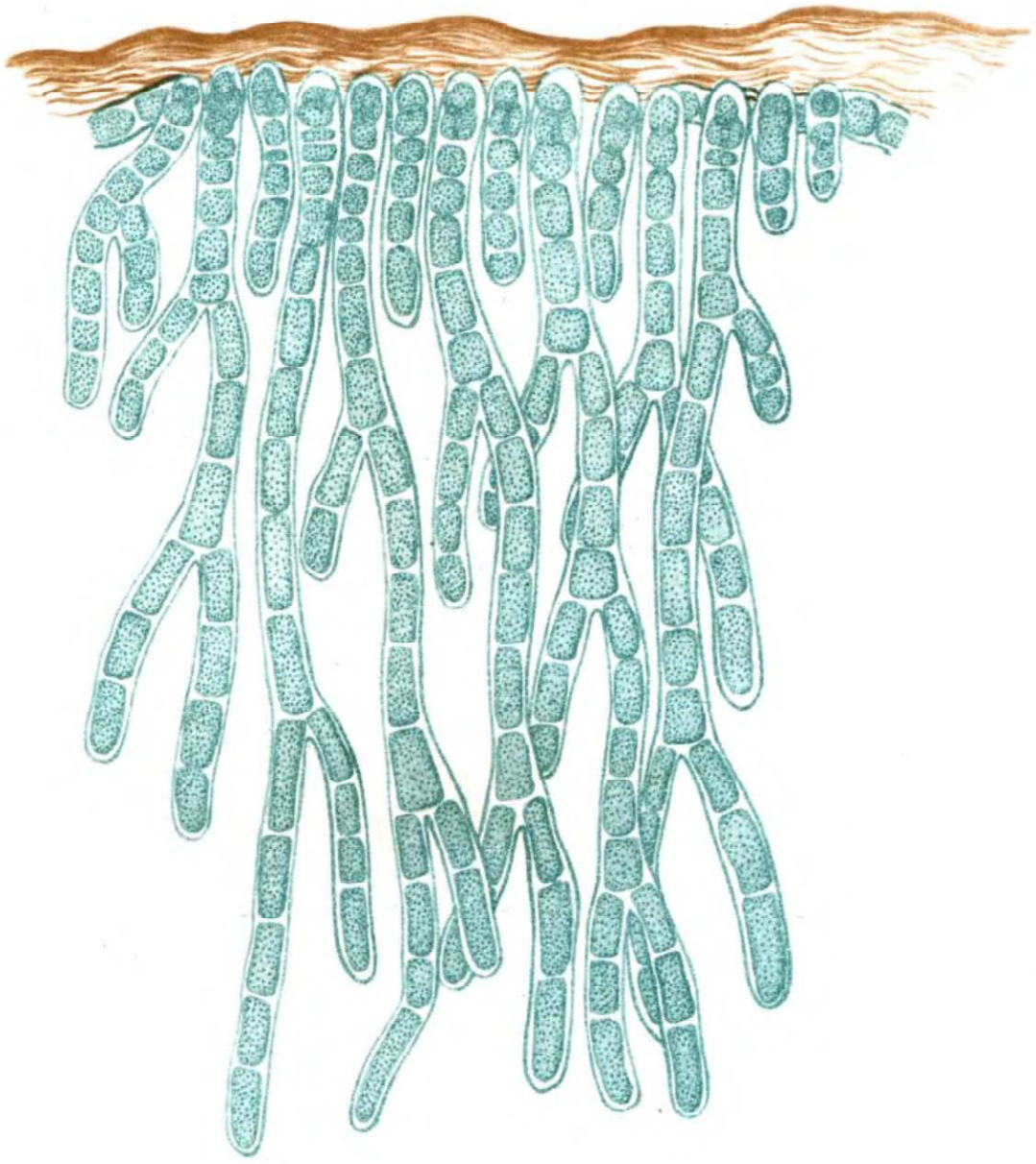
PHAEOPHILA DENDROIDES (Crouan) Batters.
(× 350)

HYELLA CAESPITOSA Born. et Flah.

Plants endolithic, growing for major part or totally perforating into hard calcareous substrata, shells of Molluscs, *Balanus*, corals and coralline algae, occurring as tiny patches. *Primary thallus* with prostrate portion of horizontally creeping filaments; *filaments* short forming pseudo-parenchymatous structures. *Perforating filaments* arising from the prostrate filamentous structure, erect, long, perforating into shells and calcareous substrata, yellowish green, yellowish brown or blue-green in colour. *Walls of filaments* gelatinous, lamellated. *Filaments* reaching up to 100-200 μ long, end cells very much elongated upto 60 μ long. *Cells of perforating filaments* in single row, 4-10 μ broad. *Sporangia* intercalary or terminal, much enlarged, pyriform in shape. *Endospores* formed by successive divisions, spherical, 2 μ in diameter.

Habitat : Endolithic, boring into the hard shells of *Balanus tintinnabulum* and other shells of Molluscs etc. Mahabalipuram, near Madras. Occurring in various shells, throughout Indian coasts.

The microscopic blue-green alga illustrated here is a fine example of the lime-boring and endolithic algae of our coast, flourishing inside the hard substrata of shells, corals and coralline algae, by actively boring their way into the hard host tissues. By gently and carefully dissolving the calcareous portions of the shells etc. with weak acids, the tissue after washing and mounting on a slide would clearly bring out the endolithic alga beautifully under the microscope. How the very delicate threads of the alga penetrate into the shells etc. is not definitely known. This alga is reported from various localities in the Pacific, Atlantic and Indian Ocean coasts.



HYELLA CAESPITOSA Born. et Flabh.
(× 470)

BACILLARIOPHYTA

The organisms illustrated in this Plate constitute but an infinitely small portion of a vast assemblage of exceedingly minute microscopic organisms, commonly known as Diatoms. Diatoms are to be found in a variety of situations and in different habitats. They inhabit sea or fresh water and play a very important role in the aquatic vegetation of the World. Diatoms may be uni-cellular or occurring as colonial plants; they occur as free-floating Planktons or as Epiphytes on a variety of hosts or on damp mud and other terrestrial situations. However, as Plankton they are more abundant in Oceans and especially in cold latitudes. Some are adapted to live in hot springs.

The cell-walls of Diatoms are silicified, some rather feebly and others very strongly. They also show remarkable sculpturings which render Diatoms as objects of great beauty under the microscope. Diatom cells which are usually referred to as *frustules* have a wall of two equal halves, the *epitheca* and the *hypotheca*, the former fitting closely over the latter. Diatoms present two views under the microscope, the *valve-view* and the *girdle-view*. The *valve view* vary much in shape according to genera and species. Several have circular valve-views and are radially symmetrical as in *Coscinodiscus*. They constitute the *Centricae* diatoms. The *Centricae* diatoms are more abundant in sea than in fresh water and they also reach larger dimensions than the fresh water diatoms. Some show in *valve-view* triangular outline as in *Triceratium*. In several others, the valves are iso-bilateral as in *Pennatae* Diatoms as in *Navicula*.

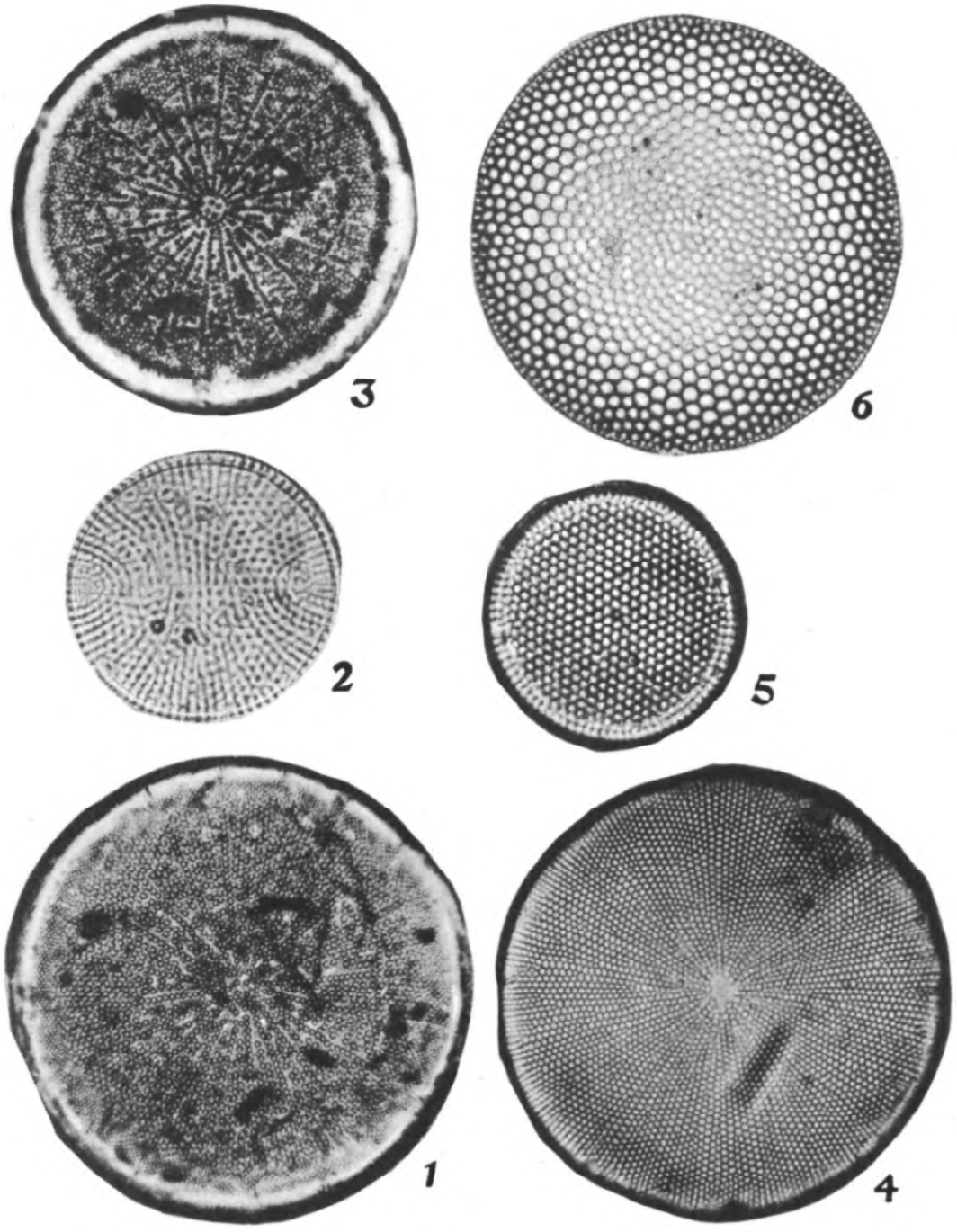
The minute sculpturings on the valves are in the form of *striae* or small dots and *punctae*. Complexity of cell-structure and markings is obtained in many ways.

Diatoms multiply by *auxospores* or by formation of *gametes* which conjugate forming a *zygote*. *Apogamy* is also known. *Microspores* by successive division is also seen in some.

Diatoms exhibit movements also, which may be simple creeping or by steady jerks, or rolling or gliding.

Diatoms constitute the chief food of many fresh water and marine fauna, *molluscs*, *crustaceans*, *tunicates*, *fishes* etc. Several species are also known in fossil forms. Diatoms also contribute largely to the oceanic and lacustrine deposits and more especially in the Arctic and the Antartic. Diatom deposits or diatomaceous earth known also as "*Kieselghur*" are chiefly found in rocks of *Tertiary* age. The Californian deposits are dated *Cretaceous*. Deposits are also known from Europe and America. The best known deposits being in British Isls., in Wales, Ireland, and in U.S.A. and Richmond in Virginia. In some Western States of America, deposits of very great thickness of more than 100 metres with 80% silica are known. The earliest fossil diatom appears to be in Triasic in Hungary.

Some of the deposits are of economic importance, being used as polishing powders—"*Tripoli*" powder. They are also used as non-conducting materials, in the manufacture of dentifrices etc. In some regions in British Isls. and Scotland, Diatomaceous forms occurring in guano, are largely imported as manure from Peru and Arfica for cereal crops. Because of their very fine markings on the cell-wall, Diatoms are used to test the high resolving power of microscope lens.



Figs: 1. *Actinocyclus* sp. 2. *Diploneis sphaerica*. 3. *Actinocyclus* sp. 4. *Coscinodiscus gantitrus*. 5. *Coscinodiscus lineatus*. 6. *Coscinodiscus oculusiridis*.

BACILLARIOPHYTA

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CORRIGENDA

The magnifications for the Colour Plates Nos. I-LI in *Phycologia Indica*, Vol. I. are to be read as indicated below:

Name of Species	*Plate No.*	*Magnification*
Gastroclonium iyengarii Srinivasan	I	× 1¾
Botryocladia leptopoda (J. Ag.) Kylin	II	× ½
Botryocladia skottsbergii (Boergs.) Levr.	III	× 5
Neurymenia fraxinifolia (Mert.) J. Ag.	IV	× ¾
Dictyurus purpurascens Bory	V	× 1
Asparagopsis taxiformis (Delile) Collins & Harvey	VI	× 1
Heterosiphonia muelleri (Sond.) De Toni	VII	× 1
Coelarthrum opuntia (J. Ag.) Boergs.	VIII	× 1
Scinaia furcellata (Turn.) Bivonia	IX	× 1
Scinaia hatei Boergs.	X	× 1
Scinaia indica Boergs.	XI	× ½
Champia indica Boergs.	XII	× 1
Helminthocladia clavadosii (Lamour) Setch. f. *indica* Desikachary	XIII	× ½
Sebdenia polydactyla (Boergs.) Balakrishnan	XIV	× ½
Solieria robusta (Grev.) Kylin	XV	× ½
Liagora erecta Zeh	XVI	× ½
Halymenia porphyroides Boergs.	XVII	× ½
Halymenia venusta Boergs.	XVIII	× ¾
Grateloupia indica Boergs.	XIX	× ⅜
Grateloupia lithophila Boergs.	XX	× ¾
Hypoglossum spathulathum Kutz.	XXI	× 1
Rhodymenia australis Sonder	XXII	× 1
Rhodymenia palmata Grev.	XXIII	× ½
Ectocarpus breviarticulatus J. Ag.	XXIV	× 1
Myriogloea sciurus (Harv.) Kuck.	XXV	× ½
Padina tetrastromatica Hauck	XXVI	× ½
Hydroclathrus clathratus (Bory) Howe	XXVII	× 1
Colpomenia sinuosa (Roth) Derbes & Solier	XXVIII	× 1
Rosenvingea intricata (J. Ag.) Boergs.	XXIX	× 1
Dictyota atomaria Hauck	XXX	× ⅝
Dictyota bartayresiana Lamour.	XXXI	× 1
Stoechospermum marginatum (Ag.) Kutz.	XXXII	× ½
Spathoglossum asperum J. Ag.	XXXIII	× ⅝
Dictyopteris australis Sonder	XXXIV	× ½
Dictyopteris woodwardii (Br.) J. Ag.	XXXV	× 1
Cystophyllum muricatum (Turn.) J. Ag.	XXXVI	× ½
Hormophysa triquetra (C. Ag.) Kutz.	XXXVII	× ⅜
Tydemania expeditionis Weber-van-Bosse	XXXVIII	× 2
Chamaedoris auriculata Boergs.	XXXIX	× 1
Chaetomorpha media (Ag.) Kutz.	XL	× 1
Pseudobryopsis mucronata Boergs.	XLI	× 1
Boergesenia forbesii (Harv.) Feldmn.	XLII	× 1
Codium elongatum C. Ag.	XLIII	× ⅝
Avrainvillea erecta (Berkel.) Gepp	XLIV	× ⅜
Caulerpa crassifolia (C. Ag.) J. Ag.	XLV	× 1

Name of Species	*Plate No.*	*Magnification*
Caulerpa scalpelliformis (R. Br.) Weber-van-Bosse	XLVI	× ¾
Caulerpa serrulata (Forsk.) J. Ag. emend Boergs.	XLVII	× 1
Caulerpa sertularioides (Gmelin) Howe	XLVIII	× 1
Ulva lactuca Linn.	XLIX	× ¾
Ulva reticulata Forsk.	L	× 1
Corynomorpha prismatica (J. Ag.) J. Ag.	LI	× ¾

In page 1 of Text, under *Gastroclonium iyengarii* Srinivasan, in 2nd line, for "2 cm thick", please read as "2 mm thick".

Magnifications of line-illustrations in *Phycologia Indica* Vol. I, pages 1-51 should be read as follows:

Gastroclonium iyengarii Srinivasan. p. 1.
Fig. 1, × 260; Fig. 2, × 1⅔; Fig. 3, × 245. (all figs. after Srinivasan, 1960).

Botryocladia skottsbergii (Boergs.) Levr. p. 3.
Figs. 1 & 2, × 125; Fig. 3, × 125; Fig. 4, × 180; Fig. 5, × 265. (all figs. after Srinivasan, 1962).

Neurymenia fraxinifolia (Mert.) J. Ag. p. 4.
Fig. 1, × 560; Fig. 2, × 750; Fig. 3, × 625; Fig. 4, × 165; Fig. 5, × 625; Fig. 6, × 1225; Fig. 7, × 275. (all figs, after Boergesen, 1933).

Dictyurus purpurascens Bory. p. 5.
Fig. 1, diagramatic; Fig. 2, × 14; Fig. 3, × 15; Fig. 4, × 12; Fig. 5, × 55; Fig. 6, × 8. (all figs. after Svedelius, 1946).

Champia indica Boergs. p. 12.
Fig. 1, × 5 ; Fig. 2, × 25. (after Boergesen, 1933).

Helminthocladia clavadosii (Lamour) Setch. *f. indica* Desikachary. P. 13.
Figs. 1-6, for 20 μ in scale, read as 10 μ (all figs. after Desikachary, 1957).

Sebdenia polydactyla (Boergs.) Balakrishnan. p. 14.
Fig. 2, for 20 μ in scale, read as 15 μ. Fig. 3, for 10 μ in scale, read as 6 μ. (Fig. 1, after Boergesen, 1932; Figs. 2 & 3, after Balakrishnan, 1961).

Solieria robusta (Grev.) Kylin. p. 15.
Fig. 1, × 120. (adapted after Anand, 1943).

Liagora erecta Zeh. p. 16.
Fig. 1, × 200; Fig. 2, × 400; Fig. 3, × 562; Fig. 4, × 500; Fig. 5, × 365. (all figs. after Balakrishnan, 1955).

Halymenia porphyroides Boergs. p. 17.
Figs. 1 & 2, × 600. (after Boergesen, 1932).

Grateloupia indica Boergs. p. 19.
Fig. 1, for 20 μ in scale, read as 12 μ; Fig. 2, for 10 μ in scale, read as 6 μ; Fig. 3, for 20 μ in scale, read as 12 μ; Fig. 4, for 10 μ in scale, read as 6 μ. (all figs. after Balakrishnan, 1961).

Grateloupia lithophila Boergs. p. 20.
Fig. 1, × 2240; Fig. 2, × 730; Fig. 3, × 2240; Figs. 4, 5 & 6, × 1050. (All figs. after Balakrishnan).

Hypoglossum spathulatum Kuetz. p. 21.
Figs. 1-3, × 9; Fig. 4, × 50. (after Boergesen, 1932).

Padina tetrastromatica Hauck. p. 26.
Fig. 1, × 220 ; Figs. 2 & 3, × 375; Fig. 4, × 100. (Figs. 1-3, after Boergesen, 1930; Fig. 4, after Srinivasan, 1960).

Rosenvingea intricata (J. Ag.) Boergs. p. 29.
Fig. 1, × 185; Fig. 2, × 195; Fig. 3, × 208; Fig. 4, × 200; Fig. 5, × 350; Fig. 6, × 210; Fig. 7, × 210. (all figs. after Srinivasan, 1960).

Tydemania expeditionis Weber-van-Bosse. p. 38.
Fig. 1, × 9; Fig. 2, × 11; Fig. 3, × 10; Fig. 4, × 7. (all figs. after Srinivasan, 1954).

Chamaedoris auriculata Boergs. p. 39.
Fig. 1, × 15; Fig. 2, × 20; Figs. 3 & 4, × 10. (after Boergesen, 1933).

Chaetomorpha media (Ag.) Kuetz. p. 40.
Fig. 1, × 30; Fig. 2, × 100; Fig. 3, × 200.

Pseudobryopsis mucronata Boergs. p. 41.
Fig. 1, × 55; Fig. 2 (left) × 185; (right) × 470. (after Boergesen, 1930, 1935).

Boergesenia forbesii (Harv.) Feldmn. p. 42.
Figs. 1-3, × 80. (after Iyengar, 1938).

Ulva lactuca Linn. p. 49.
Fig. 1, × 500; Fig. 2, × 120.

Corynomorpha prismatica (J. Ag.) Ag. p. 51.
Fig. 1, for 10 μ in scale, read as 7 μ; Fig. 2, for 10 μ, read as 5 μ; Fig. 3, for 20 μ, read as 10 μ; Fig. 4, for 20 μ, read as 6 μ; Fig. 5, for 20 μ, read as 6 μ; Fig. 6, for 10 μ, read as 4 μ; Fig. 7, for 20 μ, read as 6 μ; Fig. 8, for 10 μ, read as 4 μ. (all figs. after Balakrishnan, 1962).